HANDBOOK OF HYGIENE

AND

SANITARY SCIENCE

A

HANDBOOK OF HYGIENE

AND

SANITARY SCIENCE

BY

GEORGE WILSON, M.A., M.D. & C.M. (EDIN.), F.C.S.

MEDICAL OFFICER OF HEALTH FOR THE MID-WARWICKSHIRE
SANITARY DISTRICT

FORMERLY MEDICAL OFFICER H.M. CONVICT PRISON, PORTSMOUTH

THIRD EDITION

GREATLY ENLARGED, AND IN MANY PARTS RE-WRITTEN

PHILADELPHIA

LINDSAY AND BLAKISTON

1877

PREFACE TO THE THIRD EDITION.

THE first edition of this work, which appeared not long after the passing of the Public Health Act 1872, was so favourably received that a second was called for within six months, and this too has been out of print for nearly a year. The delay in the preparation of the present edition, although to me a matter of deep regret, is in great measure due to my desire to make the work still more worthy of continued confidence, and to spare no pains in incorporating all the more important facts and details connected with the recent rapid progress of sanitary science.

In the preface to the first edition I expressed my great indebtedness to the standard work of the late Dr. Parkes, and I wish now to acknowledge what his own kindliness of heart and diffident nature would not permit me to acknowledge before—that it was under his encouragement that the work was first written, and that all the proof-sheets were submitted to him at his own request as they issued from the press. To an

untried author in sanitary science such counsel as his was invaluable; and though I might eulogise his memory in other and more eloquent terms, I cannot do so more sincerely than by expressing, in this simple way, my heartfelt obligations to him, which never can be forgotten.

Amongst other numerous works which I consulted in the preparation of the first edition, I desire especially to mention Mr. Simon's Reports to the Privy Council; Dr. Letheby's work on food; Captain Douglas Galton's work on the construction of hospitals; and the writings of Dr. Carpenter, Dr. Angus Smith, Dr. Hassall, Mr. Rawlinson, Mr. Eassie, and Professor Rankine. Full acknowledgment of other authors is given in the proper places.

In the preparation of the present edition I have to acknowledge my obligations to the *Sanitary Record, Public Health, Lancet, British Medical Journal, Medical Times and Gazette, Practitioner*, and, more especially with regard to systematic details and authentic information of all kinds, to Mr. Simon's new series of Reports to the Local Government Board, the Sixth Report of the Rivers' Pollution Commissioners, and the more recent Reports of the State Board of Health of Massachusetts.

Every chapter has been carefully revised and amended, several have been entirely re-written, and a

chapter has been added on water-analysis, for the revision of which I have to express my thanks to Dr. Bond of Gloucester. Although I have endeavoured to cancel wherever I could without impairing the completeness of the work, and have striven to be concise throughout, the amount of new matter which has been added or interpolated has increased the size of the volume by more than a hundred pages. Notice has been taken, or excerpts made, of all the more important of the recent outbreaks of disease which have been traced to polluted milk, polluted water, or foul air; and a large amount of new information has been inserted in respect to water-supply, drainage and the disposal of sewage, sanitary engineering, infectious hospitals, and preventive measures. The passing of the Public Health Act 1875 has also necessitated the re-writing of the chapter on the duties of medical officers of health, and in addition to many new practical hints derived from my own experience and that of other health officers concerning these duties, I have written a special section on the important subject of vital statistics. Instead of the excerpt of the Sanitary Acts which appeared in the appendix of the two previous editions, but which is now no longer required, I have inserted a number of official memoranda kindly supplied to me by Dr. Buchanan, Assistant-Medical Officer of the Local Government Board, and have

added other data which it is hoped will prove equally valuable.

Although the work has been specially prepared for the use of medical officers of health, I have so arranged it that it may be welcomed as a text-book of sanitary science by medical students, and, as a handy book of reference, by medical practitioners generally. In practical details and freedom from technicalities it is also designed to be serviceable to sanitary authorities, sanitary engineers, architects, town-surveyors, sanitary inspectors, and, in short, to all those outside the profession who are interested in sanitary progress.

For the encouraging and kindly tone of all the criticisms which have reached me, I have, in conclusion, to express my warmest thanks.

G. W.

LEAMINGTON, *Dec.* 1876.

CONTENTS.

CHAPTER I.—INTRODUCTORY.

PUBLIC HEALTH AND PREVENTABLE DISEASE.

CHAPTER II.

FOOD.

CHAPTER III.

AIR: ITS IMPURITIES AND THEIR EFFECTS ON PUBLIC HEALTH.

CHAPTER IV.

VENTILATION AND WARMING.

CHAPTER V.

EXAMINATION OF AIR AND VENTILATION.

CHAPTER VI.

WATER.

CHAPTER VII.

WATER ANALYSIS.

CHAPTER VIII.

IMPURE WATER, AND ITS EFFECTS ON PUBLIC HEALTH.

CHAPTER IX.

DWELLINGS.

CHAPTER X.

HOSPITALS.

CHAPTER XI.

REMOVAL OF SEWAGE.

CHAPTER XII.

PURIFICATION AND UTILISATION OF SEWAGE.

CHAPTER XIII.

THE EFFECTS OF IMPROVED DRAINAGE AND SEWERAGE ON PUBLIC HEALTH.

CHAPTER XIV.

PREVENTIVE MEASURES—DISINFECTION.

CHAPTER XV.

THE DUTIES OF MEDICAL OFFICERS OF HEALTH.

APPENDIX.

[redacted]

CHAPTER I.—INTRODUCTORY.

PUBLIC HEALTH AND PREVENTABLE DISEASE.

PUBLIC HYGIENE may be defined as that branch of sanitary science which concerns the physical condition of communities. It embraces a consideration of the various influences operating upon society, whether for its material good or its actual deterioration, with the view of extending the former, and preventing, or ameliorating, as far as possible, the effects of the latter. It involves the enactment of laws by which the safety of the whole may be protected against the errors of a part, and, above all, it aims at the prevention of disease by the removal of its avoidable causes. In a wide sense, therefore, the science of public hygiene enlists the services of the people themselves in continuous efforts at self-improvement; of the teachers of the people, to inculcate the best rules of life and action; of physicians in preventing as well as curing disease; and of lawgivers, to legalise and enforce measures of health-preservation. But while it is the special province of the medical profession, as guardians of the public health, to study the causes of physical deterioration and disease, and to point out how far these causes may be controlled or averted, the general well-being of the people must mainly depend on their own exertions and self-restraint.

Sanitary improvements in man's material surroundings will not compensate for social transgressions against laws of morality; for public virtue is essential to public health, and both to national prosperity.

The time, however, has gone by when people can be dragooned into cleanliness or be made virtuous by police regulations, and hence it is that the most thoughtful among practical reformers of the present day base their hopes of sanitary progress on the education of the masses as the real groundwork of national health. The people must be taught that good conduct, personal cleanliness, and the avoidance of all excesses, are the first principles of health-preservation; that mental and physical training must go hand in hand in the rearing and guidance of youth; and that morality does not consist so much in a blind observance of the formulæ of empty creeds as in a hearty submission to precepts of health. Nor is this all. They must be interested systematically in the general results of sanitary progress, and become more intimately acquainted with the social and material causes by which it is impeded. Unless a knowledge of these fundamental principles of hygiene be widely disseminated amongst them, it is in vain to expect that legislative enactments, however well devised, will succeed in raising the standard of public health to any considerable extent. But there are hopeful signs of progress even in this direction. The teaching of physiology and the laws of health, which is being gradually introduced into many schools, will doubtless be productive of much good amongst the rising generation; while the large share of attention which the discussion of sanitary questions is already receiving in the public press is the best evidence of

the steady growth of intelligent conviction as regards all matters affecting the preservation of health and the prevention of disease.

Taking, then, this wide view of the scope of public hygiene, the subject of public health and preventable disease may be briefly discussed under the following sections:—

I. Hereditary Influence.
II. Causes of Deterioration and Disease.
III. Preventable Disease.

SECTION I.—HEREDITARY INFLUENCE.

Although there are many biologists who do not accept the Darwinian theory of "Pangenesis" in its entirety, there are few amongst them who dispute the influence of heredity which it serves so fully to explain. As regards the individual, the term heredity is the expression of the fact that a man is wholly built up of his own and ancestral peculiarities, and so far as these are concerned, it matters little or nothing what were the characteristics of the early progenitors of his race. In other words, the accumulation of individual variations through recent descent has a far greater influence upon a man's bodily and mental constitution than the unchanged gifts of a remote ancestry, so much so, indeed, that these latter may be regarded as a vanishing quantity. This result of the Darwinian theory has been conclusively demonstrated by Mr. Galton in his work on *Hereditary Genius*, and it is especially valuable as affording a clear and succinct conception of the influence of heredity in all cases in which individual variations lie well within the limits of stability of a race.

According to this view, the progeny is invariably moulded by the characteristics of its more recent ancestry, and by those of the parents more than by those of its grand-parents, and so on backwards in a constantly decreasing ratio. It also tends to show that *personal* characteristics or peculiarities, however much they may apparently differ from those of immediate progenitors, are not so independent as might at first sight be supposed; that they are, in reality, modified "segregations" of what already existed, either partly or wholly, in a latent condition.

But without pursuing the subject too far into the regions of controversy, it will suffice for the present purpose to adduce some of the more important opinions which are entertained by leading biologists concerning the influence of heredity, alike on body and mind, in health and disease. These may be summarised as follows:—

1. The influence of both parents on the bodily constitution of the offspring is manifested in personal resemblances, such as, stature, similarity of features, walk, gesture, colour of hair, etc. Some of the children may bear a greater resemblance to the father, others to the mother; but it is rare to meet with any instances in which some distinctive characteristics of both parents cannot be traced.

2. The influence of the other more immediate progenitors on the bodily constitution of the offspring is manifested by the resemblances which constitute the phenomenon known as atavism, which may be explained in this way:—A man, for example, does not inherit all the characteristics of either his father or his mother, and of those which he does inherit, only some

are developed, whilst others remain latent, and are probably developed in a brother or sister. His son, however, may in turn inherit the same characteristics, but with this difference, that those which were latent in the father become fully developed in him, so that he comes to bear a stronger resemblance to a grand-parent or some other relative, as an uncle or aunt, than to his father or mother.—(*A Physician's Problems*, by Dr. Elam.)

3. The influence of race, or special type, in heredity, is manifested by the constancy of averages, under tolerably constant conditions, from generation to generation, and this not only as regards the whole body and its various component parts, but also as regards all the facts which are comprised in the wide range of social and vital statistics.

4. Deviations from these averages or from the normal type, although they are transmissible, cannot transcend certain limits. Thus, as regards size, the giant and dwarf form the extreme links of the chain; and hence, in the procreation of individuals representing these deviations, the tendency to revert to the normal type is invariably manifested in the offspring.

5. As all forms of deterioration or disease may be regarded as deviations, or perverted life-processes, they are likewise subject to limitation in transmission, and there is the same tendency exhibited to revert to normal type under improved conditions. Thus, all chronic diseases appear to be transmissible, either as a morbid tendency or in their general form, such diseased heritage being well exemplified in the case of gout, scrofula, phthisis, syphilis, and insanity; but by adopting suitable measures, the disease may be finally eradicated from the family, or the morbid tendency be

overcome. It has also to be remembered that a hereditary disease or a morbid tendency may remain latent, like any other characteristic, for one or two generations, and become developed in the next.

6. Mental and moral qualities, if indeed they can be separated, are subject to the same law of heredity as other personal characteristics, with this important addition, that any vicious habit or tendency in the parents becomes, as a rule, intensified in some form or other in the offspring. With regard to mental capacity, Mr. Galton has clearly demonstrated, in the work already referred to, "that a man's natural abilities are derived from inheritance, under exactly the same limitations as are the form and physical features of the whole organic world;" and Herbert Spencer, Morel, Dr. Maudsley, and many others, uphold that a man's mental *incapacity* is similarly conditioned,—that perversion or absence of the moral sense is, in effect, as much a portion of some men's inheritance as their height or weight. In no class of persons is the truth of this doctrine better exemplified than amongst habitual criminals;—their strong impulses and feeble wills, their vicious propensities and absence of moral sense, which constitute the fate of their heritage, render them more or less irresponsible members of society.

7. Any particular characteristic, especially if it be of the nature of a deterioration or taint, when common to both parents, is liable to be intensified in the offspring. It is on this account that marriages between blood-relations are inadvisable, inasmuch as latent morbid tendencies, should they form part of the organic patrimony of the family, are almost certain to become developed in the children.

Such being the influence of heredity on man's physical, mental, and moral being, what, it may be asked, are its bearings on public health? Briefly these—that each generation has enormous power over the well-being of those that follow; that acquired habits, whether for good or evil, may become more or less permanent in a race, the good being slowly developed and with difficulty retained, the evil readily implanted and with difficulty eradicated. It shows also that deterioration, however produced, as it affects families, may affect communities, in an ever-widening circle, until a whole race may become degenerate and disappear from amongst nations.

SECTION II.—CAUSES OF DETERIORATION AND DISEASE.

These may be divided into two classes—namely, social and material. As the material causes will be more or less fully discussed in succeeding chapters, the mere enumeration of the more important of them will suffice here, such as impure air, impure water, insufficient or unwholesome food, dampness of soil, deficiency of warmth, etc. The removal of these causes is the principal aim of practical hygiene as enforced by legislative enactments. The social causes of deterioration and disease, on the other hand, are little, if at all, controlled by State interference; and hence their removal, as far as possible, must depend mainly on individual or combined efforts dictated by a sense of duty, which may be either egoistic or philanthropic, as the case may be. It is here that the effects of education, whether imparted in the family circle and school, or from the

pulpit and platform, or by the public press, will be tried and tested.

In a country such as this the social causes of deterioration and disease are multiform and intricate. Intemperance, immorality, injudicious marriages, excesses of every description, overwork, idleness, depressing passions, may be enumerated as the most disastrous. All of them tend to impair the constitution of the individual, or the well-being of the offspring, and in proportion to their prevalence they lower the standard of public health. Obviously, it is difficult to dissociate their separate effects in their influence on public health, because they seldom operate singly even in isolated cases. The intemperate man, for example, if not otherwise immoral, is too often housed in a home where the air is poisoned by overcrowding, and from which comfort and cleanliness are alike banished. And if it be urged that the unhealthy home is the result of the intemperance, it may also be affirmed that sometimes it is the cause, and that this, in the first place, may have been induced by an early or imprudent marriage. These, however, are speculations on which it is needless to enter, for the broad results, as affecting the well-being of society, are sufficiently distinct, and may be discussed more or less fully in detail.

1. *Intemperance.*—That the habitual use of alcoholic liquors, even though it be seldom carried to the verge of intoxication, deteriorates the health, and is liable to result in actual disease, is a statement which few will be found to contradict. The main point at issue is rather, whether, for the great majority of healthy persons, habitual abstinence is not the best rule to be laid down. This question has been answered very strongly

in the affirmative by Dr. Carpenter and other eminent authorities, not only on physiological grounds, but because extended experience has proved that whatever temporary augmentation of power may result from their occasional use, prolonged bodily or mental labour can be best sustained without them. The careful and exhaustive experiments conducted by the late Dr. Parkes also tend to the same conclusion, and go very far to prove that not only is alcohol not a necessity, but that its use, even in small quantities, is not desirable in most cases. No doubt, when the diet is insufficient, or the digestion feeble, the moderate use of stimulants is decidedly beneficial; but as this applies to alcohol more as a therapeutic, than as a dietetic, agent, it would be out of place here to enter further into this part of the subject.

With regard, however, to the habitual and excessive use of alcoholic liquors, amounting to intemperance, the gravity of the effects admits of no question. Digestion is interfered with, the physical strength is undermined, and the nervous system becomes seriously impaired. The result of this nervous exhaustion is manifested by the tremulousness of the hands, the twitchings of muscles, and, above all, by the enfeebled will, which, in many cases, becomes powerless to resist the craving for drink which is ultimately induced. Moreover, the perversion of the nutritive processes leads to fatty degeneration of the heart and blood-vessels, of the kidneys, liver, and other parts; and side by side with this diseased condition of body there is gradual loss of self-control, with perversion of the moral sense, so that, in many instances, the habitual drunkard becomes eventu-

ally a veritable dipsomaniac, whose only chance of cure is restraint in an asylum.

But these effects, grave though they be, do not end with the individual, for the law of heredity brands the offspring as victims of a diseased organisation, manifesting itself especially in a vitiated nervous system. For example, the craving for drink may itself be inherited, or the thieving and cunning propensities developed in the parent to obtain stimulants at all hazards, may become so intensified in the offspring as to render him a born thief and vagabond. Or, again, the parent's loss of mental power and moral discrimination may become displayed in the child as hopeless idiocy or some other form of insanity. Obviously, it is not easy to collect accurate statistics in support of these statements, but the following will suffice for illustration:—Out of 300 idiots in the State of Massachusetts, whose histories were carefully investigated by Dr. Stowe, as many as 145 were the offspring of intemperate parents. Further, speaking in general terms, M. Morel, than whom no higher authority can be quoted, says, "I constantly find the sad victims of the alcoholic intoxication of their parents in their favourite resorts, the asylums for the insane, prisons, and houses of correction. I as constantly observe amongst them deviations from the normal type of humanity, manifesting themselves not only by arrests of development and anomalies of constitution, but also by those vicious dispositions of the intellectual order which seem to be deeply rooted in the organisation of these unfortunates, and which are the unmistakable indices of their double fecundation in respect of both physical and moral evil."

Not to dwell longer on this topic, I would briefly state that my own experience amongst convicts has fully convinced me that four-fifths of the prison-population are directly or indirectly the victims of intemperance;—directly, as regards the occasional, and indirectly, to a large extent, as regards the habitual, criminals. In other words, the great majority of the former lapse into crime through acquired drunken habits, while the great majority of the latter are congenitally criminal on account of the intemperance of their progenitors.

As regards the effects of intemperance in this twofold aspect on the public health, it is impossible to arrive at any accurate conception; but that the general sick-rate and death-rate of the population are both very largely increased by this cause alone, there can be no doubt. Indeed the growth of resolute conviction, which is at present observable amongst the more intelligent classes, with respect to the abuse of alcohol, is the best evidence alike of the universality of the evil, and its danger to the well-being of the community.

2. *Immorality.*—Although licentiousness is happily not so prevalent in this country as to be productive of extensive deterioration and disease, it is instructive to note how it has in former times told upon the fate of nations. And history furnishes no warning more sad and terrible than that displayed by the downfall of ancient Greece. How came it to pass that this highly-gifted race, which had attained to a standard of intellectual superiority as far exceeding ours of the present day as ours exceeds that of the African negro, decayed and disappeared? The answer, which is given in Mr. Galton's words, is not far to seek—"Social morality

grew exceedingly lax; marriage became unfashionable, and was avoided; many of the more ambitious and accomplished women were avowed courtesans, and consequently infertile, and the mothers of the incoming population were of a heterogeneous class. In a small sea-bordered country, where emigration and immigration are constantly going on, and where the manners are as dissolute as were those of Greece in the period of which I speak, the purity of a race would necessarily fail."—(*Hereditary Genius.*)

3. *Injudicious or Unsuitable Marriages.*—This cause of deterioration refers to the marriage of persons who, from their condition in life, are unfit to rear a family, or who, from age, constitution, or consanguinity, are liable to procreate a diseased offspring. It will be at once seen that this subject touches the very foundation of a nation's prosperity and growth. For, in the first place, unthriftiness in marriage amongst all classes may lead in the long run to an increase of population which will exceed the means of healthy subsistence, just as it leads to poverty and disease in any case when a man can barely earn what is sufficient for his own wants. To quote Dr. Acland—"The reality of our difficulty about population is told in a few words—England and Wales are increasing by about 200,000 annually. This number will, of course, increase by a small increment. Since A.D. 1810, the population, which was, 10,000,000, has become, 22,000,000; and, at the same rate, will become by A.D. 1920 over 45,000,000. The acres in England and Wales are about 37,325,000, including waste ground. There are now, therefore, nearly two acres per man; there will be in fifty years not one; in Glasgow, there are already 94 inhabitants to an acre;

and in Liverpool, 103."—(*Lecture on National Health.*) Already, then, it may be said, the effects of over-population are threatening the well-being of the nation; and though it be true that emigration affords an outlet for numbers, the question arises whether the country is not drained of the useful and vigorous, rather than of its less useful and deteriorated, inhabitants.

Then, again, this unthriftiness in marriage prevails most extensively amongst the ignorant and degenerate, or, at all events, amongst those of the lower orders who hover on the verge of pauperism. They look upon parish relief as a prescriptive right if they beget more children than they can rear; and, in many instances, when once they do become pauperised, the system of relief encourages family increase, because the more numerous the children, the greater is the sum obtained for the use of the family generally. It is quite true that the improvement which is steadily taking place in the administration of out-door relief is doing much to remove many of the abuses attaching to the system; but it essentially encourages improvidence, want of forethought, and disregard of connubial responsibility and proper parental care. There is no doubt also that the frightful mortality amongst the children of the lower working classes who do not receive parish relief is not altogether to be attributed to defective sanitary arrangements or to insufficient nourishment. In many instances there is intentional neglect, amounting to culpable homicide, for the remedies prescribed for the sick child are not administered, while the medical comforts obtained from the dispensary or from charitable persons for its recovery are appropriated by the parents. The child, at the best, is

allowed to die, or its death is hastened, because its existence is felt to be a troublesome burden. Truly, the old Spartan barbarity of exposing weak and ailing children to certain death is still put in practice, even in civilised nations, and to an extent which only those who have done dispensary work in our large cities can well conceive.

This is one phase of the consequences of unthriftiness or imprudence in marriage. But there is another, which perhaps operates as a cause of sickness and mortality with equal severity—the practice, namely, of prolonging the period of weaning the child until the mother becomes weak, and her constitution, in all probability, permanently impaired; and this preventive check, which is well known amongst all classes, tells on the child as well as the mother; so that, in her anxiety not to beget too many children, she unconsciously ruins the health of those she already has begotten.

No wonder, in the face of such evils as these, that Malthus and others should have proposed a series of checks to prevent the procreation of large families, and amongst these should have insisted strongly on the advisability of delaying the period of marriage. But, as Mr. Galton has shown, even this check, were it adopted, would operate to the detriment of a mixed community, inasmuch as it is advanced as a course for the prudent to follow, while the imprudent are left to act as they please. "Its effect would be such as to cause the race of the prudent to fall, after a few centuries, into an almost incredible inferiority of numbers to that of the imprudent, and it is therefore calculated to bring utter ruin upon the breed of any country where the doctrine prevailed. . . . It may seem

monstrous that the weak should be crowded out by the strong; but it is still more monstrous that the races best fitted to play their part on the stage of life should be crowded out by the incompetent, the ailing, and the desponding."—(*Hereditary Genius.*)

Turning, now, to the other part of the subject—namely, the effects of *unsuitable* marriages—it may be stated at the outset that too early or too late marriages are punished by sterility, or by the procreation of offspring afflicted with a lowered vitality. M. Quetelet's deductions on this point, from a large number of statistics (see *Physique Sociale*), are as follows:—

(1.) Too early marriages result in sterility, or in the birth of children whose chance of surviving to the average period of life is lessened.

(2.) Marriages which are not infertile are productive of the same number of children, independently of age, provided that the average age of the husband does not exceed 33 years, nor that of the wife, 26. After these ages the number of children diminishes.

(3.) The greatest fecundity attends the marriage of men under 33 years of age to women under 26.

(4.) Other things being equal, those marriages are most fertile in which the age of the husband at least equals that of the wife, or does not greatly exceed it.

To these deductions might be added those of Dr. Matthews Duncan and others, which go to prove that, apart from fecundity, the health of the mother, and consequently of the offspring, has a less chance of being deteriorated by delaying the woman's age of marriage to 25 or 26 years.

But the most disastrous results connected with unsuitable marriages are those in which morbid tendencies

are found to form part of the organic patrimony of one or both parents. If, for example, the parents both spring from consumptive families, the chances are that the whole of the offspring will become victims to the disease: or, again, even should one of the parents come of a healthy stock, the danger to the offspring is by no means removed, although it is lessened; many of the children may escape, but it is seldom that they all do so. The same remarks apply to scrofula, and indeed, more or less, to all diseases of a chronic or adynamic nature. It is chiefly, however, in relation to so-called mental affections that the mischief of unsuitable marriages becomes apparent, for, according to Dr. Burrows, the percentage of cases due to hereditary influence reaches 84.

As regards consanguine marriages, it has already been shown that, inasmuch as any latent morbid tendency is likely to be the same in both parents, the danger of such tendency becoming developed in the offspring is greatly increased. But, apart from the existence of any latent tendency, too close breeding amongst human beings, as amongst animals, invariably leads to deterioration, and ultimate extinction. Hence it is that ancient aristocracies, reduced to repeated intermarriage, have become first degenerated physically, and have become finally extinct, sometimes by drifting into imbecility or dementia, or, at all events, by becoming infertile. The following statistics will, however, illustrate more fully the sad heritage to which the offspring of consanguine marriages are doomed:—Amongst the children proceeding from 121 marriages of this description, M. Devay found that 22 were sterile, 27 deformed, and 2 were deaf mutes. Out of 34 marriages, investi-

gated by Dr. Bemiss of Louisville, 7 were found to be infertile. From the 27 fertile marriages, 192 children were born; of these 58 perished in infancy or early life. Of the 134 who arrived at maturity, 46 appeared to be healthy, 32 deteriorated, 23 were scrofulous, 4 epileptic, 2 insane, 2 dumb, 2 blind, 4 imbecile, 2 deformed, 5 were albinos, 6 had defective vision, and 1 had chorea. The remainder were not reported on as regards physical condition. Dr. Howe's statistics, already referred to, are still more decided:—Out of 17 marriages between blood relations, resulting in the birth of 95 children, he found that 44 were idiots, 12 scrofulous, 1 deaf, 1 a dwarf, and only 37 who enjoyed tolerable health. M. Boudin, again, has calculated that whilst consanguine marriages in France only amount to 2 per cent of the whole number, the deaf and dumb children resulting from these marriages amount to nearly a quarter of the whole number. (See *A Physician's Problems*, by Dr. Elam.)

It would be easy to multiply these instances, but enough has been said to demonstrate how powerfully imprudent or unsuitable marriages must operate as a cause of deterioration and disease on the public health. All these points, however, must become generally known and fully realised before any amelioration can be expected; and though it be true that some writers look forward to the time when State interference may be exercised in this as in other directions, it is doubtful whether it would not give rise to evils greater than those which it would tend to repress.

Leaving out of consideration the mode of operation of other causes of deterioration, and merely glancing at the broad results when the material as well as

social causes are taken into account, it becomes at once apparent that, whether the English race is or is not deteriorating as a whole, it is certainly exposed to this danger. Indeed, the constantly increasing preponderance of town population over rural population in numbers, and the fact that the average *physique* of the former is considerably below that of the latter, renders it highly probable that the standard is becoming imperceptibly lowered. At present, according to Dr. Beddoe's valuable statistics, the average stature of adult Englishmen of all classes is about 5 feet 6·6 inches (without shoes), but unfortunately there are no data by means of which any comparison can be made between this average and the average say, of fifty, or one hundred years ago. Inferences can, therefore, only be drawn from the different statistics of the town and country populations of the present day, and these point conclusively to deterioration, even admitting the influence of original breeds. Thus, to take the returns from Cumberland and Westmoreland, exclusive of Carlisle, given in Dr. Beddoe's statistics, as representative of a country population, it appears that the average height is 5 feet 8·1 inches; whereas, in the neighbouring county of Lancashire, where the true native breeds used also to be undeniably tall, the average is as low, or lower, than that of England generally. But while the evidence of physical deterioration is manifest in the town-bred population, it becomes still more pronounced in the degenerate classes of the community. Thus, I find that the average height of the 316 convicts received into Portsmouth prison during 1871 is 5 feet 5·0 inches; and Dr. Beddoe's statistics of the lunatics in

London, Birmingham, and Nottingham, yield an average somewhat below this.

If, however, there is reason to fear that the average *physique* of the English race, in the rapid growth of town populations, has of late years become lowered, there are good grounds for believing that the deterioration has reached its culminating point. Already the results of sanitary improvements in many of our large towns are beginning to declare themselves, not only in a lessened sick-rate and death-rate, but in an apparently healthier tone of public opinion. The working classes in all parts of the country have been bestirring themselves for more leisure and more pay, and so far they have succeeded. It remains to be seen whether the leisure will be spent in self-improvement, or the extra pay be judiciously applied, and not worse than wasted. Savings' banks, Good-Templarism, the present diminution of pauperism and crime, are all of them hopeful signs; but it must not be forgotton that holidays and high wages may prove to be a curse instead of a blessing, if they are spent in lawless drinking bouts, and not according to the precepts of health and morality.

SECTION III.—PREVENTABLE DISEASE.

The remarks in the preceding section, fragmentary though they be, suffice to show that, apart from the mortality and sickness arising from material causes, such as impure air, impure water, or insufficient food, there is a vast amount of preventable disease attributable to social causes, which legislative measures, or ordinary sanitary precautions, do not reach. So far as these causes are concerned, the hopes of progress and

improvement, as already stated, must rest on education wide-spread and general. The fundamental principles of personal and domestic hygiene must become matters of intelligent conviction amongst all classes, and especially amongst the upper and middle, that they may help those of the lower who are unable to help themselves. For it cannot be denied that there are multitudes in all our large towns so heavily burdened with the load of a vitiated heritage, and so hemmed in with the barriers of foul air, filth, and want, that teaching and preaching can only be felt as bitter mockeries unless these barriers are first removed. Herein lie the duties of sanitary authorities, and in their ready enforcement of the powers vested in them by the legislature, there is at last some hope that amelioration and enlightenment may penetrate even to these depths.

But limiting the estimate of preventable disease to the operation of causes removable by ordinary sanitary administration, the waste of life is still as needless as it is appalling. This, however, is a tale of culpable neglect, which requires no comment, and is best told in the words of the medical officer of the Local Government Board:—"It seems certain," writes Mr. Simon in 1871, "that the deaths which occur in this country are fully a third more numerous than they would be if our existing knowledge of the chief causes of disease were reasonably well applied throughout the country; that of deaths, which in this sense may be called preventable, the average yearly number in England and Wales is about 120,000; and that of the 120,000 cases of preventable suffering which thus in every year attain their final place in the death-register, each unit represents a larger or smaller group of other cases in

which preventable disease, not ending in death, though often of far-reaching ill effects on life, has been suffered. And while these vast quantities of needless animal suffering, if regarded merely as such, would be matter for indignant human protest, it further has to be remembered, as of legislative concern, that the physical strength of a people is an essential and main factor of national prosperity; that disease, so far as it affects the workers of the population, is in direct antagonism to industry; and that disease which affects the growing and reproductive parts of a population must also in part be regarded as tending to deterioration of the race.

"Then there is the fact that this terrible continuing tax on human life and welfare falls with immense over-proportion upon the most helpless classes of the community; upon the poor, the ignorant, the subordinate, the immature; upon classes which, in great part through want of knowledge, and in great part because of their dependent position, cannot effectually remonstrate for themselves against the miseries thus brought upon them, and have in this circumstance the strongest of all claims on a legislature which can justly measure, and can abate, their sufferings.

"There are also some indirect relations of the subject which seem to me scarcely less important than the direct. For where that grievous excess of physical suffering is bred, large parts of the same soil yield, side by side with it, equal evils of another kind, so that in some of the largest regions of insanitary influence, civilisation and morals suffer almost equally with health. At the present time, when popular education (which indeed in itself would be some security for

better physical conditions of human life) has its importance fully recognised by the legislature, it may be opportune to remember that, throughout the large area to which these observations apply, education is little likely to penetrate, unless with amended sanitary law, nor human life to be morally raised while physically it is so degraded and squandered." (See *Thirteenth Report of the Medical Officer of the Privy Council.*)

Or, to take another illustration. According to the returns of the Registrar-General, there are fifty-four large tracts of England and Wales whose annual mortality-rate is only seventeen per 1000, less by *five* than the average mortality-rate of the whole country, less by *ten* than in nine districts, and less by *twenty-two* than the mortality reigning for ten years in Liverpool. It therefore appears that there are influences inimical to life prevailing to a far greater extent in some parts of the country than in others, and a closer analysis of the national death-register demonstrates still more clearly that this excess of mortality is, for the most part, due to diseases which in other ways are known to be preventable, and which detailed medical inspections in various localities, at the instance of the Privy Council and the Local Government Board, have proved to be dependent upon causes which are not only removable, but whose very existence constitutes an offence against sanitary law. These causes have been grouped by Mr. Simon into two great classes, namely, local conditions of filth and nuisance polluting air and water, and reckless disseminations of contagion; and as regards both these wide fields of disease-causation, the Public Health Act of 1872, and still more recently the Consolidated Health Act of 1875, have conferred

extensive powers upon sanitary authorities throughout the country to remove the former and to see that protective measures and penal checks are fully and fairly carried out with regard to the latter. In proportion to the faithful discharge of these obligations will the public health be improved and the general death-rate of the kingdom lowered.

CHAPTER II.—FOOD.

SECTION I.—FUNCTIONS AND CONSTITUENTS OF FOOD.

WITHOUT entering into a discussion of the various chemico-physical changes which food undergoes in the living body, it may be broadly asserted that its ultimate destiny is the development of heat and other modes of motion, which together constitute the physiological phenomena of animal life. The potential energy with which the food is stored becomes converted into actual or dynamic energy, and is manifested in the body as heat, constructive power, nervo-muscular action, mechanical motion, and the like. But as food also supplies the materials which are requisite for the development and maintenance of the living fabric, as well as for the display of its various kinds of active energy, it may be inferred that inorganic and organic substances are both necessary. The organic alone are oxidisable, or capable of generating force, while the inorganic, though not oxidisable, are essential to the metamorphosis of organic matter which takes place in the animal economy.

The organic constituents of food are generally divided into nitrogenous, fatty, and saccharine compounds; and the inorganic into water and saline matters. Both classes of constituents are present in all ordinary articles of diet, whether they be derived from the animal or vegetable kingdom.

1. *Functions of the Nitrogenous Constituents.*—The nitrogenous constituents consist of albumen in its various forms, fibrine, syntonin or muscle-fibrine, casein, gluten, legumin, and other allied substances, such as gelatine. Their chemical composition is remarkably uniform, and, as they seem all capable of being reduced by the digestive process to a like condition, they can replace each other in nutrition, though not to an equal extent.

Up to a comparatively recent period, it was believed that nitrogenous constituents must first be converted into tissue before their dynamical energy can be elicited; in other words, that muscular force is entirely dependent on the metamorphosis of muscular tissue, and that urea, being the product of the change, ought to be regarded as a measure of the force. This was the doctrine taught by Professor Liebig, and it was generally accepted by physiologists until Drs. Fick and Wislicenus of Zurich published their famous experiments connected with their ascent of the Faulhorn. While these experiments proved that a non-nitrogenous diet will sustain the body during severe exercise for a short period, and without any notable increase in the amount of urea, the more carefully-conducted experiments subsequently made by Dr. Parkes showed that *possibly* the amount of urea is even lessened. If this view were confirmed, Dr. Parkes' inference would be rendered highly probable—the inference, namely, that muscle, instead of oxidising during labour, and becoming wasted by losing nitrogen, does in reality appropriate nitrogen, and grows, and that its exhaustion does not depend so much on decay for the time being, as on an accumulation of the oxidised products of other food-constituents

within its tissues. He takes care to point out, however, that in the long run some decay of muscle does take place, and that the amount of nitrogen must be increased as the work increases. The still more recent researches of Dr. Pavy in the case of Mr. Weston, so well known for his pedestrian feats, appear to indicate that at the commencement of a prolonged muscular effort, the nitrogen excreted is considerably increased, and that subsequently it will vary pretty much according to the amount contained in the food consumed from day to day.

Judging from these and other experiments, it would therefore appear that, although the main functions of the nitrogenous constituents of food are the construction and repair of the tissues, they exercise other important functions of a regulative and dynamic nature not well defined. There is no doubt that a certain portion of them is directly decomposed in the blood, and so far they contribute to the maintenance of animal heat and the development of dynamic energy; but the experiments of Pettenkofer and Voit also tend to show that the nitrogenous substances composing the tissues determine the oxidation of the other constituents, or, in other words, that no manifestation of force is possible without their participation in the process.

2. *Functions of the Fatty Constituents.*—The fact that food containing a large proportion of fatty ingredients is invariably used by the inhabitants of cold countries, indicates that these constituents play an important part in the maintenance of animal heat. Indeed, it has been proved by experiment that the respiratory or heat-producing powers of fat are twice and a half as great as those of the other hydrocarbons,

as starch or sugar. Fat also takes an active share in the conversion of food into tissue, and aids the removal of effete products from the system. The experiments already alluded to likewise show that its oxidation in the blood generates to a great extent the force which is rendered apparent in locomotion or manual labour. Further, its distribution in the tissues gives rotundity to the form, serves to retain animal heat by its non-conducting properties, and greatly facilitates the working of the various parts of the living machine by lessening friction and preventing jarring by its elasticity.

3. *Functions of the Saccharine Constituents or Hydrocarbons.*—These constituents comprise cellulose, starch, and sugar; and, like the fatty constituents, are directly subservient to the maintenance of animal heat and the production of animal force. Starch is for the most part converted into dextrine, and by a further oxidation generates carbonic acid, which is given off by the lungs. As already stated, the heat-producing powers of these constituents are much inferior to those of fat, but they are capable of being converted into fat in the system, and are largely concerned in carrying on the digestion of nitrogenous substances.

4. *Functions of Water and Saline Matters.*—The principal functions of water in the animal economy are—the solution and conveyance of food to different parts of the system, the removal of effete products, the lubrication of the tissues, the equalising of the body temperature by evaporation, and the regulation of the chemical changes which take place in the processes of nutrition and decay. Saline matters, on the other hand, are the chief media for the transference of the organic constituents throughout the body. They are

largely concerned in the consolidation of the tissues, and are supposed to convert unabsorbable colloids into highly diffusive crystalloids.

The functions of what are called the accessories of food, such as beverages, stimulants, etc., are still matters of speculation.

That all these four classes of constituents should be present in a well-arranged dietetic scheme is alike taught by experience and proved by experiment. No single class is capable of sustaining life by itself, although it is certain that health can be maintained for some time on a diet consisting of the nitrogenous, fatty, and saline matters.

The separate amounts and relative proportions of the several classes of constituents required in a standard diet for a healthy male European adult, of average size and weight, and performing a moderate amount of work, are given in the following table:—

Amounts.		Grammes.	Relative Proportions.
Water-free Substances given daily.	Ounces avoir.		
Nitrogenous substances .	4·587	130	1
Fatty ,, .	2·964	84	·6 nearly.
Saccharine ,, .	14·257	404	3
Saline ,, .	1·058	30	·2
Total water-free food .	22·866	648	

Although no single standard will meet all cases, the above, which is quoted from Moleschott's numbers, is found to accord fairly with the observations of numerous other physiologists.

SECTION II.—NUTRITIVE VALUES OF FOOD.

As the phenomena of nutrition depend mainly on the chemical interchanges of nitrogen and carbon with oxygen, different articles of diet have been estimated according to the amount of nitrogen and carbon which they contain. But inasmuch as the actual value of the carbonaceous compounds in fatty constituents is about two and a half times as great as that of the saccharine constituents, it is evident that, in framing a table of alimentary equivalents, the amount of carbon must be stated as having the same nutritive value throughout. In the following table, therefore, which is taken from the late Dr. Letheby's valuable work on *Food*, the amount of carbonaceous matters in the different articles of diet is estimated as starch:—

	GRS. PER POUND.	
	Carbon.	Nitrogen.
Split Peas .	2699	248
Indian meal .	3016	120
Barley meal .	2563	68
Rye meal . .	2693	86
Seconds flour .	2700	116
Oatmeal . .	2831	136
Bakers' bread .	1975	88
Pearl barley .	2660	91
Rice . . .	2732	68
Potatoes . .	769	22
Turnips . .	263	13
Green vegetables	420	14
Carrots . .	508	14
Parsnips . .	554	12
Sugar . .	2955	—
Treacle . .	2395	—
Buttermilk .	387	44
Whey . .	154	13
Skimmed milk .	438	43
New milk . .	599	44
Skim cheese .	1947	483
Cheddar cheese .	3344	306
Bullock's liver .	934	204
Mutton . .	1900	189
Beef . . .	1854	184
Fat Pork . .	4113	106
Dry Bacon .	5987	95
Green bacon .	5426	76
White fish .	871	195
Red herrings .	1435	217
Dripping . .	5456	—
Suet . . .	4710	—
Lard . . .	4819	—
Salt butter .	4585	—
Fresh butter .	6456	—
Cocoa . .	3934	140
Beer and porter .	274	1

As this table contains almost all the articles which are likely to be met with in a common dietary, it becomes no difficult matter to calculate the total amount of carbon and nitrogen which any such dietary yields, and to compare the results with other dietaries that have been calculated in the same way. It is necessary to add that the nutritive equivalents apply to articles in their uncooked state, and that the meat is boned.

SECTION III.—FOOD AND WORK.

It has already been stated that, in addition to maintaining the body in a healthy state, the potential energy of food is the sole source of the active energy displayed in mechanical motion or work. It therefore follows that the diet must be increased as the work increases; and the question arises at the outset,—What is the minimum amount of food on which a man of average size and weight can subsist without detriment to health? From a large number of observations made by Dr. Lyon Playfair and others on the dietaries of prisons and workhouses, and by the late Dr. Edward Smith on the amounts of food consumed by the Lancashire operatives during the cotton-famine, it would appear, according to Dr. Letheby, that a barely sustaining diet should contain about 3888 grains of carbon, and 181 grains of nitrogen. In round numbers, and taking a somewhat liberal view of the question, Dr. Edward Smith has proposed the following averages, as representing the daily diet of an adult man and woman during periods of idleness:

	Carbon (grains).	Nitrogen (grains).
Adult man . . .	4300	200
Adult woman . . .	3900	180
Average adult .	4100	190

Taking the mean of all the researches which have been made by eminent physiologists, Dr. Letheby has given the following as the amounts required daily by an adult man for idleness, for ordinary labour, and for active labour :—

Daily diets for	Nitrogenous. Ozs.	Carbonaceous. Ozs.		Carbon. Grs.	Nitrogen. Grs.
Idleness .	2·67	19·61	=	3816	180
Ordinary labour	4·56	29·24	=	5688	307
Active labour	5·81	34·97	=	6823	391

Very often the standard for a healthy adult employed at ordinary labour is stated as 20 grammes of nitrogen, and 300 grammes of carbon, equivalent to 308·6 and 4629 grains respectively.

And here it may be observed that the general correctness of these averages is fully borne out by the results of the numerous experiments which have been made to ascertain the amount of carbon and nitrogen actually excreted by adult men under different conditions of diet and exercise. These results have also been summarised by Dr. Letheby, and the averages are found to correspond very closely with those just given, thus :—

Daily Requirements of the Body (LETHEBY).

		Nitrogenous Food. Ozs.	Carbonaceous Food. Ozs.		Carbon. Grs.	Nitrogen. Grs.
During Idleness as determined	By dietaries	2·67	19·61	=	3816	180
	By excretions	2·78	21·60	=	4199	187
	Average	2·73	20·60	=	4005	184
Routine work as determined	By dietaries	4·56	29·24	=	5688	307
	By excretions	4·39	23·63	=	4694	296
		4·48	26·44	=	5191	302

The actual amounts of carbonaceous and nitrogenous matters which are consumed by low-fed and well-fed operatives are given in the following tables:—

Weekly Dietaries of Low-fed Operatives, calculated as Adults (Dr. E. Smith).

Class of Labourer.	Bread stuffs.	Potatoes.	Sugars.	Fats.	Meat.	Milk.	Cheese.	Tea.	Containing Carbon.	Containing Nitrogen.
	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Grs.	Grs.
Needle Women (London)	124·0	40·0	7·3	4·5	16·3	7·0	0·5	1·3	22,900	950
Silk-weavers (Coventry)...........	166·5	33·7	8·5	3·6	5·3	11·6	1·0	0·3	27,028	1104
Silk-weavers (London)	158·4	43·8	8·8	5·5	11·9	4·3	0·3	0·6	48,288	1165
Silk-weavers (Macclesfield)........	138·8	26·6	6·3	3·4	3·2	41·9	0·9	0·3	27,346	1177
Kid-glovers (Yeovil)	140·0	84·0	4·3	7·1	18·3	18·3	10·0	0·9	28,623	1213
Cotton-spinners (Lancashire)......	161·8	22·6	14·0	3·1	5·0	11·8	0·7	0·7	29,214	1295
Hose-weavers (Derbyshire)........	190·4	64·0	11·0	3·9	11·9	25·0	2·2	0·4	33,537	1316
Shoemakers (Coventry)	179·8	56·0	10·0	5·8	15·8	18·0	3·3	0·8	31,700	1332
Farm labourer (England)	196·0	96·0	7·4	5·5	16·0	32·0	5·5	0·5	40,673	1594
Farm labourer (Wales)	224·0	138·7	7·5	5·9	10·0	85·0	9·8	0·5	48,354	2031
Farm labourer (Scotland)..........	204·0	204·0	5·8	4·0	10·3	124·8	2·5	0·7	48,980	2348
Farm labourer (Ireland)............	326·4	92·0	4·8	1·3	4·5	135·0	—	0·3	43,366	2434
Mean of all...........	184·2	78·1	8·0	4·5	10·7	42·9	3·1	0·6	34,167	1500
Average per day	26·3	11·1	1·1	0·6	1·5	6·1	0·4	0·1	4,881	214

Daily Dietaries of well-fed Operatives (PLAYFAIR).

Class of Labourer.	Flesh-formers.	Fats.	Starch and Sugar.	Containing		Containing	
				Carbon-aceous.	Nitro-genous.	Carbon.	Nitro-gen.
	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Grs.	Grs.
Fully fed tailors	4·61	1·37	18·47	21·64	4·61	5136	325
Soldiers in peace	4·22	1·85	18·69	22·06	4·22	5246	297
Royal Engineers (work) . . .	5·08	2·91	22·22	29·38	5·08	6494	358
Soldiers in war .	5·41	2·41	17·92	23·48	5·41	5561	381
English sailor .	5·00	2·57	14·39	20·40	5·00	4834	252
French sailor .	5·74	1·32	23·60	26·70	5·74	6379	405
Hard-worked weavers . .	5·33	1·53	21·89	25·42	5·33	6020	375
English navvy (Crimea) . .	5·73	3·27	13·21	21·06	5·73	5014	404
English navvy (Railway) . .	6·84	3·82	27·81	37·08	6·84	8295	482
Blacksmiths. .	6·20	2·50	23·50	29·50	6·20	6864	437
Prize-fighters (training) . .	9·80	3·10	3·27	10·70	9·80	4366	690
Mean of all .	5·81	2·42	18·63	24·31	5·81	5837	400
Mean of low-fed operatives .	3·04	0·64	21·18	22·78	3·04	4881	214

As an addendum to these data, and by way of contrast, I may here give some particulars with reference to the dietaries of the convicts confined in English prisons. In the hard-labour prisons, where the great majority of the prisoners are employed at active outdoor work, there are two scales of diet—viz., the light-labour diet, and the full-labour diet. I have carefully calculated the nutritive values of the various articles of food contained in these diets, according to the equivalents given in a preceding table, and the results are as follows:—

	Daily Average.	
	Carbon. Grs.	Nitrogen. Grs.
Light-labour diet . . .	4651	224
Full-labour diet . . .	5289	255

What is called light labour applies to manual work requiring very little muscular exertion, while full labour embraces a variety of occupations, such as tailoring, shoemaking, artisan work, and navvy work. From the averages already given, it will be inferred that the light-labour diet is quite sufficient for the easy nature of the work, and, practically, with few exceptions, this is found to be the case. The prisoners employed at light labour are all more or less invalid or crippled, and although almost all of them could take more food, they are not found to lose weight, except in isolated cases. With regard to the practical working of the full-labour diet, however, this much cannot be said; for while prisoners employed at comparatively easy labour, such as artisan work, do not lose weight to any extent, those employed at the more arduous kinds of labour, such as navvy work, almost invariably lose a great deal, and after a time must be removed to lighter work to recruit. In whole gangs of prisoners employed at filling and wheeling barrows of clay, for example, I have found an average loss of weight of over 13 lbs. per prisoner, the loss accruing within a period of about two months after they had been put to such work. The consequence is, that in a hard-labour prison the convicts must be continuously shifted from hard to lighter work, and, after recruiting, from lighter to hard, otherwise they would completely break down, on account of the insufficiency of the full-labour diet for the severer kinds of prison labour. In military prisons, according to Dr. Letheby, where the dietary contains as much as 5090 grains of carbon and 256 grains of nitrogen daily, even for short periods of confinement, many of the prisoners lose weight, and give evidence of other signs of decay, so

that it is found necessary to increase the diet for longer periods to 6362 grains of carbon and 317 of nitrogen. Of course, military prisoners require more food than convicts, independently of the nature of the work at which they may be employed, inasmuch as they are larger men, and the ordinary physiological wants of the body demand a proportionately greater amount of nutriment. But the difference in stature between the two classes of prisoners does not account for such a difference in diets, and I have no doubt that convicts employed at active out-door labour would require at least as much as is represented by the average diet for ordinary labour given by Dr. Letheby—viz. a diet containing 5688 grains of carbon and 307 grains of nitrogen daily, to maintain them in good health, and prevent serious loss of weight.

Section IV.—Construction of Dietaries.

By reference to the numerous data already given, it will not only be easy to calculate the nutritive value of any given dietary, but a reliable opinion may be formed as to its suitability as well as sufficiency under specified circumstances. It now remains to point out the more important principles which ought always to be kept in view in the construction of dietaries; and, apart from the influence of work, which has already been considered, they may be briefly summarised as follows:—

1. *Influence of Sex.*—In the case of in-door operatives, the dietaries of women should be about one-tenth less than those of men.

2. *Influence of Age.*—Up to nine years of age, a child should be dieted chiefly on milk and farinaceous substances. At ten years of age it will require half as

much nutriment as a woman; and at fourteen quite as much as a woman. Young men who have not reached their full growth, but who are doing the same amount of work as adult men, require more food than the latter.

3. *Selection of Food.*—This embraces a variety of considerations, such as—

(1.) *The relative proportions of proximate constituents.* —These have already been shown in Moleschott's numbers, and they correspond very closely with those given by Dr. Letheby—viz. 22 of nitrogenous substances, 9 of fat, and 69 of starch and sugar. Whether the diet be mixed or purely vegetable the same proportions hold good, and the results of experience prove that they are substantially correct. For example, articles of food which are deficient in one class of constituents, are invariably associated with others which contain an excess of them. Thus we have butter, or milk, or cheese, with bread; bacon, with veal, liver, and fowl; melted butter or oil, with fish; and so on. Such combinations are also of great service in aiding the digestibility of food. For reasons to be afterwards stated, every dietary should contain fresh vegetables.

(2.) *Variety of Food.*—But even when the proper proportions of constituents are provided for in a dietary, it is further necessary that certain articles belonging to the same class be varied from day to day, otherwise the appetite cloys. Beef should alternate with mutton, for example; or variety may be secured by different modes of cooking the same article. Indeed, it is not too much to say that the art of cookery is a matter of national importance, not only because it renders food palatable, but because the more it is studied and practised the greater is the economy which may be effected. It is

chiefly in this respect that beverages, condiments, etc., become such valuable dietetic adjuncts.

(3.) *Digestibility.*—This also in great measure depends upon the mode of cooking.

(4.) *Price.*—For much practical information on this and other points, see Dr. Edward Smith's *Practical Dietary*, or his Report on the Food of the Lancashire Operatives, in the Fifth Report of the Medical Officer to the Privy Council.

4. *Number and distribution of Meals.*—Experience teaches that three meals daily are best suited to the wants of the body. Dr. Edward Smith, in his physiological diet of 4300 grains of carbon and 200 of nitrogen, distributes the amounts as follows:—

	Carbon.	Nitrogen.		Carbonaceous.	Nitrogenous.
	grs.	grs.		oz.	oz.
For Breakfast . .	1500	70	=	6·62	1·04
For Dinner . . .	1800	90	=	7·85	1·34
For Supper . . .	1000	40	=	4·52	0·59
Total daily . .	4300	200		18·99	2·97

5. *Climate.*—Other things being equal, carbonaceous substances ought to contain a preponderance of fatty constituents in cold climates, and of starchy or farinaceous, in warm climates. This also applies to seasonal variations.

SECTION V.—PRESERVED FOODS.

Only a few of these need be mentioned.

1. *Liebig's Extract.*—This is more especially valuable to the traveller or the invalid. According to Dr. Parkes it is very restorative, removing all sense of fatigue after great exertion. Its nutritive qualities are inferior to those of ordinary beef-tea, but it can often be

taken by an invalid when beef-tea would be rejected; and it has the further advantage of being readily prepared.

2. *Preserved Meat.*—What is known as Australian meat has the most extensive sale. Weight for weight, it is not so nutritious as properly cooked fresh meat, because the process of preservation requires that it should be over-cooked. The great difference in price, however, more than compensates for this slight disadvantage, and on the score of economy alone it deserves to be extensively used. Large quantities of it are now consumed in workhouses and asylums. It is best used cold, or warmed and mixed with potatoes and vegetables to form a stew; or it may be minced and warmed. In Dr. Williams' experiments in the Sussex County Asylum, the patients were allowed amounts equal to the uncooked fresh meat daily ration, with the result of a slight gain in weight in 13 of the 20 experimented on at the end of a month, the weight of the others remaining stationary.

3. *Preserved Vegetables.*—When fresh vegetables cannot be procured in sufficient quantity, dried vegetables should be employed to make up the deficiency. In lieu of potatoes in the early part of summer, preserved potatoes may be used, but as they are apt to pall on the appetite, other substitutes, such as a mess of rice and cabbage, pease-pudding, or haricot beans, should be given on alternate days.

4. *Preserved Milk.*—According to recent analyses conducted by Mr. Wanklyn, the condensed milk prepared by the Anglo-Swiss, Newnham's, and the English Condensed Milk, Companies, consists of pure milk sweetened with a little sugar. As one volume of the condensed milk contains the nutritive material of four

volumes of fresh milk, it should be diluted with three times its volume of water when used.

SECTION VI.—EXAMINATION OF FOOD.

It need scarcely be said at the outset that a thorough practical knowledge of the qualities and appearances presented by the various articles of diet, in their wholesome or unadulterated state, is a necessary qualification for the detection of unwholesome or adulterated specimens.

1. *Meat.*—The characters of good meat may be enumerated as follows:—

(1.) On section, it should present a marbled appearance from intermixture of streaks of fat with muscle. This shows that the animal has been well fed.

(2.) The colour of the muscle should neither be too pale nor too dark. If pale and moist, it indicates that the animal was young or diseased; and if dark or livid, it shows that in all probability the animal was not slaughtered, but died with the blood in it.

(3.) Both muscle and fat should be firm to the touch, not moist or sodden, and the latter should be free from hæmorrhagic points.

(4.) Any juice exuding from the meat should be small in quantity, be of a reddish tint, and give a distinctly acid reaction to test-paper. Good meat should dry on the surface after standing a day or two. The juice of bad meat is alkaline or neutral.

(5.) The muscular fasciculi should not be large and coarse, nor should there be any mucilaginous or purulent-looking fluid to be detected in the intermuscular cellular tissue.

(6.) The odour should be slight, and not by any means disagreeable. An unpleasant odour indicates commencing putrefactive change, or that the meat is diseased. By chopping a portion of the meat into small pieces, and afterwards drenching it with warm water, any unpleasantness of odour will be more readily detected. Another good plan is to thrust a long clean knife into the flesh, and smell it after withdrawal.

If the meat is at all suspicious, the muscular fibre should be examined under the microscope. The smaller *cysticerci* and *trichinæ* can only be detected in this way. The brain and liver should also be examined for hydatids, the lungs for multiple abscesses, and the ribs for pleuritic adhesions. To detect cattle-plague, the mouth, stomach, and intestines should be examined.

Bad meat is usually sodden and flabby, with the fat dirty or gelatinous-looking, and the smell unpleasant or sickly.

I may here mention that it is the practice in the City of London to condemn the flesh of all animals infected with parasitic disease, such as measles, flukes, etc.; of animals that may have been suffering from acute, febrile, or wasting diseases; and of those which have died from natural causes or by accident; as well as all meat tainted with physic, or in a high state of putrefaction. It is also the practice to condemn the flesh of any animal which has been killed immediately before, during, or immediately after parturition, on the presumable grounds that an animal would not be slaughtered under such circumstances unless, from some cause or other, death appeared to be impending. A case of this description was tried at Lincoln in March, 1873, which I quote here as a case in point:—It appears

that on a certain farm a sheep was killed by the shepherd, because, as he said, it was unable to lamb from excess of fat, and was ill in consequence. The carcase was dressed and sold to the defendants at a low price, but when exposed for sale was seized and condemned as unfit for food. On the evidence of Dr. Tidy, who was called as a skilled witness, the defendants were sentenced to pay a fine with costs, or be imprisoned for one month.

Bad-smelling sausages, or sausages which have a nauseous or putrid taste, a very acid reaction, or a soft consistence in the interior, are highly dangerous, and should always be condemned. So too with fish which has become sodden or discoloured, and which gives off an offensive or ammoniacal odour.

It may here be noted that in apportioning rations of meat, 20 per cent must be allowed for bone. The loss in weight by cooking varies from 20 to 30 per cent.

2. *Flour.*—What is called good household flour or "seconds" should contain very little bran, be quite white, or only slightly tinged with yellow, and should give no acidity or musty flavour to the taste. It should not be lumpy or gritty to the touch, nor should it yield any odour of mouldiness to the sense of smell. When made into a paste with a little water, the dough should be coherent and stringy.

The amount of gluten can be ascertained by washing carefully a known quantity of flour, made first into a rather stiff dough, until the water comes off quite clear. The gluten, when baked or dried, should be clean-looking, and should weigh at least 8 per cent of the quantity of flour taken for examination. A good flour will yield 10 to 12 per cent. Bad flour gives a

dirty-looking gluten, which is deficient in cohesion, and cannot be drawn out into long threads.

Flour is sometimes adulterated with barley-meal, maize, rice, potato-starch, etc. Samples of doubtful quality should therefore be examined microscopically. *Fungi, vibriones,* and the *Acarus farinæ,* are detected in flour which is undergoing putrefactive change.

3. *Bread.*—The crust should be well baked, not burnt. The crumb should not be flaky or sodden, but regularly permeated with small cavities. The taste and smell should both be agreeable, and free from acidity. Unless there is a considerable quantity of bran in the flour, the colour should be white, not dark or dirty-looking.

Good flour, well baked, yields about 136 lbs. of bread per 100 lbs. of flour, and adulteration is chiefly directed to increase this ratio by making the gluten hard, and the bread more retentive of water. This the dishonest tradesman effects by adding alum, copper sulphate, or a gummy mixture of ground rice. The bread may be recognised by its becoming sodden and doughy at the base after standing for some time.

4. *Oatmeal.*—Good oatmeal is generally roughly ground, and contains a fair proportion of envelope freed from the husks. If husks are present, the probability is that the meal has been adulterated with barley. The starch should not be discoloured, and the meal itself should be agreeable to the palate. If the meal looks suspicious, it should be examined microscopically.

Milk.—Pure cow's milk, when placed in a tall narrow glass vessel, should be perfectly opaque, of a full white colour, free from deposit, and should yield from 6 to 12 per cent of cream by volume. As it is

frequently adulterated with water, the specific gravity is a most important test of the quality, and hence the value of the lactometer. The specific gravity varies from 1028 to 1032; if it falls below 1026 it shows that the milk is either very poor, or that a certain amount of water has been added. The following table by Dr. Letheby indicates approximately the amount of water-adulteration according to the specific gravity and percentage of cream:—

	Specific Gravity.	Percentage volume of cream.	Specific Gravity when skimmed.
Genuine milk	1030	12·0	1032
Do. with 10 per cent water	1027	10·5	1029
Do. „ 20 „ „	1024	8·5	1026
Do. „ 30 „ „	1021	6·0	1023
Do. „ 40 „ „	1018	5·0	1019
Do. „ 50 „ „	1015	4·5	1016

When milk is largely adulterated with water, other substances, such as treacle, salt, and turmeric, are sometimes added to improve the flavour and appearance; but, generally speaking, the use of a graduated glass vessel to determine the percentage of cream, and testing by the lactometer, will enable one to give a reliable opinion as to whether the milk is genuine or not.

6. *Butter.*—Butter should give no unpleasant or rancid taste. Adulteration with water or animal fats is best detected by melting the butter in a test-tube; the water, salt, or other substances remaining at the bottom. After separation of the casein by melting, good butter is entirely soluble in ether at 65° Fahr., while the fat of beef or mutton dissolves with great difficulty, and leaves a deposit. Adulteration with potato or other starch can be at once detected by iodine. Good butter, when melted, should yield a clear-looking oil, with little deposit of water or other substance.

7. *Cheese.*—The quality of cheese is determined by the taste and consistence. Inferior cheeses are often soft and leathery, owing to the amount of water which they contain. Starch, which is sometimes added to increase the weight, may be detected by iodine.

8. *Eggs.*—An average-sized egg weighs about 2 oz. avoir. Fresh eggs, when looked through, are more transparent at the centre; stale ones, at the top. In a solution of 1 of salt to 10 of water, good eggs sink, while the stale ones float.

9. *Potatoes* should be of good size, give no evidence of disease, be firm to the touch, and, when cooked, should not be close or watery.

10. *Tea.*—According to Dr. Letheby, the *bloom* or *glaze* of black and green tea is generally artificial. In the case of black tea, it sometimes consists of a coating of black-lead; and in that of green tea, it is usually a mixture of Prussian blue, turmeric, and China clay. Both kinds of adulteration are detected by shaking the leaves in cold water, straining through muslin, and afterwards examining the deposit. Inferior mixtures, such as Maloo mixture, Moning congou, Pekoe siftings, etc., are largely imported into this country, and consist of exhausted tea-leaves, leaves of other plants, iron-filings, etc., with only a little good tea.

Good tea should yield a pleasant aroma, alike in the dry state and when infused in boiling water, and the flavour of the infusion should be agreeable. If the tea is suspicious, the infused leaves should be spread out and carefully scrutinised, and any powdery deposit examined under the microscope.

11. *Coffee.*—The principal adulteration of coffee is chicory. The adulteration may be detected either by

microscopic examination or by sprinkling a portion of the suspected sample on the surface of water, when the coffee will float and the chicory sink. The presence of chicory is also indicated, if, on opening a package of coffee, the contents are found to be caked, or show any signs of caking.

Amongst other articles of food or drink which are liable to adulteration may be mentioned cocoa, mustard, pepper, confections, beer, wine, and spirits; but without entering farther into this part of the subject, it will be sufficient to point out that any article of food or drink, or any drug which is supposed to be adulterated, should be submitted to a public analyst, on whose report proceedings may be taken under the provisions of the "Sale of Food and Drugs Act, 1875."

Section VII.—The Effects of Insufficient or Unwholesome Food on Public Health.

1. The minor effects of insufficient food are generally so intimately associated with those of other causes of disease, that it is impossible to estimate, with any approach to accuracy, their separate influence on public health. For, as Mr. Simon eloquently observes, "Long before insufficiency of diet becomes a matter of hygienic concern,—long before the physiologist would think of counting the grains of nitrogen and carbon which intervene between death and starvation,—the household will have been utterly destitute of material comfort; clothing and fuel will have been even scantier than food; against inclemencies of weather there will have been no adequate protection; dwelling-space will have been stinted to the degree in which overcrowding

produces or increases disease; of household utensils and furniture there will have been scarcely any, -even cleanliness will have been costly or difficult; and if there still be respectful endeavours to maintain it, every such endeavour will represent additional pangs of hunger. The home, too, will be where shelter can be cheapest bought, -in quarters where there is commonly least fruit of sanitary supervision, least drainage, least scavenging, least suppression of public nuisances, least, or worst, water-supply, and, if in town, least light and air. Such are the sanitary dangers to which poverty is almost certainly exposed, when it is poverty enough to imply scantiness of food." And this picture, dark though it may appear, represents the condition of thousands who are struggling hard for very existence, and yet are all the while unsolicitous of relief. But when to these are added the numbers that swell the pauper list, and crowd the workhouses, with the famishing and permanently disabled, some conception may be formed of the wide-spread suffering and disease which follow in the wake of actual want.

The symptoms of failing health produced by insufficient diet, as observed in individual cases, are somewhat as follows:—There is gradual loss of flesh, advancing to extreme emaciation. The pulse becomes feeble, and the complexion sallow. Exertion brings on attacks of palpitation, vertigo, and transient blindness, until at last the patient falls a victim to some form of adynamic disease. Of this train of symptoms no more notable example could be quoted than the account given of the sanitary condition of Millbank Prison in 1823. The prisoners confined in this establishment had previously received a daily diet of 31 to 33 oz. of

dry nutriment, when it was resolved to reduce this allowance to 21 oz., and to exclude from the diet animal flesh, or nearly so. Hitherto, the prison had been considered healthy, but within a few months after the new diet-scale had been introduced, the health of the inmates began to give way, the first symptoms being loss of colour, gradual loss of flesh, and general debility. At last, numbers were attacked with diarrhœa, dysentery, and scurvy, and cases of convulsions, maniacal delirium, and apoplexy became common. About 52 per cent of the prisoners were more or less affected in this way; and to prove that the reduction of the diet was the chief, if not sole cause of the epidemic, the prisoners employed in the kitchen, and who were allowed 8 oz. additional bread daily, continued in good health, while the alarming sick-rate amongst the others was not diminished until the diet was increased.—(*Carpenter.*)

Similar observations to these were made amongst the prisoners confined in Fort Sumter during the late American war. The diet of the 30,000 inmates consisted of only $1\frac{1}{4}$ lb. meal and $\frac{1}{3}$ lb. bacon daily per head, and sometimes this allowance was reduced. As a consequence of this and other deplorable hygienic defects connected with the prison, 10,000 Federals died within a period of less than seven months, the prevailing diseases being diarrhœa, dysentery, scurvy, and hospital gangrene.—(*Carpenter.*)

Again, the terrible mortality which prevailed amongst the British troops in the Crimean war was clearly attributable to the insufficiency of the food-supply. No extra allowance was granted for the increased exertion and the exposure to cold; and the result was, that within a few months the deaths from diarrhœa, dysen-

tery, scurvy, and fever, rose to 39 per cent, and in some cases to 73.—(*Letheby.*)

As regards the civil population, the history of relapsing fever is almost exclusively a history of the ravages of disease arising from destitution; and the famines of the present century, especially those of 1817 and 1847, need only be referred to as evidence on this point. Further, the connection of scurvy with an insufficient or badly-arranged dietary is now so clearly established that it has been laid down as an axiom—the privation of vegetable food is its one essential cause, and the giving of it is its one essential counteraction.

2. *Unwholesome Food.*—There is so much uncertainty with regard to the effects of eating what is called *unsound meat* that Dr. Letheby has observed, "I feel that the question of the fitness of such meat for food is in such an unsettled state, that my action in the matter is often very uncertain; and I should like to have the question experimentally determined; for, as it now stands, we are either condemning large quantities of meat which may be eaten with safety, and are therefore confiscating property, and lessening the supply of food; or we are permitting unwholesome meat to pass almost unchallenged in the public markets." No doubt, much of the apparent immunity from disease enjoyed by the large numbers who unwittingly indulge in unwholesome food at times, is to be attributed to the antiseptic power of good cooking, but there are also many instances on record in which food of the most putrid description is devoured without producing any ill effects. Thus, according to Sir Robert Christison, there are whole tribes of savages who eat with impunity rancid oil, putrid blubber, and stinking offal; and in this country game

is not considered to be in a fit state for the epicure's table until it is undergoing rapid putrefactive change. Admitting all this, however, there is abundant evidence to prove that serious consequences resulting from the use of unsound meat are of frequent occurrence, and in all probability a large proportion of cases of obscure disease owe their origin to the same cause. Moreover, it is but only logical to conclude, from general principles, that, as all diseases must affect the composition of animal flesh, and as active putrefactive change must at all events deteriorate its nutritive value, it is of the utmost importance to health that these substances should be obtained in as sound a condition as possible.

The following is a brief abstract of the more important facts connected with this part of the subject:—

(1.) *Putrid Meat.*—On the whole, this may be said to be wasteful rather than positively injurious, but there are numerous cases recorded in which it has produced serious disease. Vomiting, diarrhœa, and low fever of a typhoidal type, are the chief symptoms. Putrid sausages are especially dangerous. According to an official return, it appears that in Wurtemberg alone, during the last fifty years, there have been 400 cases of poisoning from German sausages, and of these 140 were fatal.

(2.) *Diseased Meat.*—Here, again, the evidence is of the same conflicting character. According to Dr. Letheby, enormous quantities of the flesh of animals that died of rinderpest in 1863, and more recently of pleuro-pneumonia, have been sent to the London market, sold, and eaten, without having produced any tangible ill effects. It is also well known that Scotch shepherds indulge largely in *braxy*, or diseased mutton, with ap-

parent impunity: and, according to M. Decroix, the whole of the inhabitants of Paris would have suffered during the late siege if diseased meat were to any extent dangerous.

In the face of such evidence as this, it really becomes a question of public importance whether the flesh of *all* animals that have died diseased should be condemned. As a matter of fact, about one-fifth of the meat in the London market, according to Professor Gamgee, is of this description, and it is quite possible that, if it were sold under its true character, and proper precautions were taken with regard to selection and cooking, the ill effects which sometimes attend its use might not occur. Of course, such meat would be of inferior quality, but being so, it would be much cheaper, and within the reach of many who are sorely in want of animal flesh, but cannot buy it at its present price. As it is, however, the butcher sells it under a fictitious character, and it is therefore the duty of the health officer to condemn it.

In the numerous cases of illness which have been attributed to the use of diseased meat, the symptoms are very similar to those occasioned by the use of putrid meat. The exceptional symptoms apply chiefly to the development of parasitic disease. Thus, the *Cysticercus cellulosus* of the pig produces the *Tænia solium*, and that of the ox or cow, the *Tænia medio-canellata.* The *trichina* disease, again, which a few years ago was so prevalent in many parts of Germany and elsewhere, is due to the *Trichina spiralis* in pork; and the *ecchinoccus disease* owes its origin to the flesh of sheep and cattle which have become diseased by the tænia of the dog. It appears that all these parasites are destroyed if the meat is thoroughly cooked before being eaten.

(3.) Some kinds of fish, especially in warm weather and in hot climates, have been known to produce very severe symptoms. Thus cases of acute urticaria with swelling of the tongue, fauces, and eyelids, are frequently due to eating lobsters, crabs, or shell-fish; while gastro-intestinal irritation, sometimes of almost choleraic intensity, is by no means a rare consequence of eating putrid fish of any kind. The disease known by the Spanish name of *siguatera* is of this description, and is common amongst the crews of vessels doing duty in the tropics when they partake of fish caught at the various stations as a change from the ordinary diet of the ship.

(4.) As regards unwholesome vegetable food, it may be said that all food of this description which has become mouldy is dangerous. On the Continent, the ergot of rye has been productive of serious epidemics, and in this country alarming symptoms have frequently followed the use of flour which contains the ground seeds of *Lolium temulentum*, or darnel.

In connection with the subject of unsound food, some special notice should be taken of the spread of disease through the agency of milk. And, first, it has to be noted that the milk of animals suffering from disease, as from foot-and-mouth disease, though no doubt frequently used with impunity, sometimes produces aphthous ulceration of the mouth and gums, with swelling of the tongue, and great fœtor of the breath. Dr. Thorne Thorne reports an outbreak of this nature (see *Twelfth Report of the Medical Officer of Privy Council*), and I have myself witnessed a few well-marked cases of this description. It is true they occur with much less frequency than might naturally be sup-

posed, but at the same time it cannot be too strongly insisted on that all milk of the kind, or, indeed, any milk yielded by a cow suffering from any form of disease, should be condemned as unfit for human food. In the Western States of America, the milk of cows affected with "the trembles," believed to be produced by feeding on *Rhus toxicodendron*, has frequently been known to cause severe gastric symptoms amongst children, accompanied by great weakness and lowering of the temperature (see *Medical Times and Gazette*. 1868). In this country, very strong fears have likewise been expressed by the opponents to schemes of sewage irrigation, that the milk of cows fed on sewaged grass would be unwholesome and the butter become putrid. But, so far as I am aware, there is no well-authenticated instance of disease having been produced in this way, while I can assert to the contrary that there are large quantities of milk sold daily in and around Leamington obtained from cows fed exclusively on sewaged grass during the summer, and that on every occasion on which samples of the milk have been analysed, it has been found to be richly flavoured and of excellent quality. It may also be noted that Dr. Swete, the borough analyst, has made repeated experiments with the butter, and has found that it possesses none of those tendencies to putrefactive change which have been so gratuitously attributed to it.

But the great danger attaching to milk, as a carrier of disease, depends upon its remarkable powers of absorption and the rapid fermentive or zymotic changes which it undergoes when it becomes mixed with putrefying matter, or tainted with disease-germs. Some few years ago it was proved by Mr. Lawson Tait, and the

experiment has since been repeated by others, that milk exposed to the vapour of carbolic acid, for example, will very soon taste strongly of the acid; and, in like manner, if it be kept in any close or badly ventilated place, where foul odours are perceptible, it will very soon become tainted and unfit for use. Very probably, it is in this way that such fungi as the *Oidium lactis*, described by Fuchs, Mosler, and Hessling are generated, and it is well known that milk so affected has frequently been the cause of gastric irritation and sharp attacks of vomiting. Moreover, there can be no doubt that much of the infantile diarrhœa, which proves specially fatal during the summer and autumn months, is due to milk, which either becomes tainted in this way, or becomes tainted by being put into feeding-bottles which are seldom or never properly cleaned. Indeed, there are so many unseen dangers in the use of milk, especially amongst careless and filthy people, that, to ensure safety, it should always be boiled during warm weather and in districts where foot-and-mouth disease is prevalent. Milk should never be stored in sculleries or larders, or in vessels made of lead or zinc; in the latter case it speedily absorbs salts of the metal and becomes poisonous.

As regards the spread of specific disease, there is now an overwhelming amount of evidence which proves, beyond dispute, that milk is largely instrumental in propagating scarlatina and enteric fever; and amongst other instances may be mentioned the following:—The late Professor Bell of St. Andrews has related an outbreak of scarlet fever in that town, which showed very conclusively that the fever was distributed by the milk-carrier, or, what is more probable, that the diseased

cuticle from the woman and children who vended the milk actually passed into it, and that in this way the poison was introduced.—(*Lancet*, 1870.) Again, Dr. Taylor of Penrith gives an account of a somewhat similar outbreak, in the *British Medical Journal*, 1870, where he also reports a group of cases of enteric fever which he believed to be due to specifically infected milk. Further, Dr. Ballard (*Lancet*, 1870) records an outbreak of enteric fever in Islington, which he attributed to the washing of the milk-cans with water derived from a tank which was found to communicate with two old drains, and one of these with the pipe of a water-closet. Whether the milk was adulterated with the same water was not ascertained, but the evidence, both positive and negative, rendered it tolerably certain that the disease was propagated in this way. These outbreaks were the first of the kind which were thoroughly investigated, but since then several others have been reported; as, for example, the outbreak at Armley, a village near Leeds, investigated by Dr. Robinson and Dr. Ballard in 1872; an outbreak at East Molesey, near Birmingham, also investigated by Dr. Ballard in 1873; an outbreak at Parkhead, a suburb of Glasgow, investigated by Dr. Russell in 1873; and the well-known outbreak at Marylebone, London, the real cause of which was, in the first instance, suspected by Dr. Murchison and others, and was subsequently investigated in all its intricate bearings by Mr. Netten Radcliffe, assisted by Mr. Power. In this instance, the disease appeared within a few weeks in as many as 123 families, of whom 106 obtained their milk from a new milk company, and Mr. Radcliffe

proved with "a probability amounting for practical purposes to a certainty, that—

"(1.) The outbreak of enteric fever, which formed the subject of inquiry, was caused by milk infected with enteric fever material.

"(2.) That this came from a particular farm.

"(3.) That the water used for dairy purposes on this farm contained excremental matters from a patient suffering from enteric fever, immediately before and at the time of the outbreak."—(See Mr. Simon's *Reports*, New Series, No. II.)

Lastly, there is the recent remarkable outbreak at Eagley, near Bolton. Early in the present year, over 200 persons were attacked in and around Eagley with undoubted enteric fever, and within the space of a few weeks. It was found that those attacked, both in Eagley and in Little Bolton, derived their milk from a dairy farm belonging to a Mrs. Kershaw, that the milk itself had been "impoverished," and that there was the strongest evidence to show that it had been diluted with water impregnated with fæcal matter. Whether or not this matter contained the specific virus of enteric fever has not yet been made quite clear, although it has been ascertained that one of the men, whose excreta passed into the brook from which the water was derived, had been suffering from diarrhœa.—(*Sanitary Record*, 1876.)

Other serious outbreaks might be quoted, but these are sufficient to prove that milk is a far more frequent agent in the spread of disease than is generally suspected; and, for my own part, I am inclined to believe that many obscure cases of enteric fever, and much of the autumnal diarrhœa, which occur in rural districts,

are due to polluted milk. Indeed, several scattered cases of enteric fever have come under my own notice, in which, although there was no evidence to show that the specific virus had been introduced, it was clear enough that the well was contaminated with sewage, and that the milk-cans had been washed with the polluted well-water, even if the milk itself had not been diluted with it. All this, it need hardly be said, affords the strongest possible argument that all dairies, or places where milk is sold, should be licensed and kept under special sanitary supervision.

CHAPTER III.

AIR : ITS IMPURITIES, AND THEIR EFFECTS ON PUBLIC HEALTH.

SECTION I.—COMPOSITION.

PURE AIR, according to the numerous analyses of Dr. Angus Smith, is composed of 20·99 per cent by volume of oxygen, ·033 per cent of carbonic acid, and the rest of nitrogen, watery vapour, and traces of ammonia. With the exception of carbonic acid and aqueous vapour, the relative proportions of the other constituents remain tolerably constant throughout the globe. In this country the amount of oxygen varies from 20·999 per cent in the sea air on the coast of Scotland, to 20·910 in Manchester during frost and fog, while the carbonic acid ranges from ·03 to ·05 per cent. The following averages of analyses, quoted from Dr. Smith's work on *Air and Rain*, represent the more important variations in the open-air percentages of carbonic acid :—

	Carbonic Acid in 100 parts. Averages.
Different parts of Scotland, and at various altitudes	·0336
Perth city and outskirts	·04136
Closer parts of Glasgow	·0539
Opener parts of Glasgow	·0461
Suburbs of Manchester	·0369
Streets of Manchester	·0403
Open places of London	·0301
Streets of London	·0341
Lake of Geneva (Saussure's analysis)	·0439

It also appears that the air of the highest mountains contains more carbonic acid, less oxygen, and less organic matter, than the air of plains, and that the quantity of oxygen is always sensibly diminished in the air of towns.

The amount of aqueous vapour fluctuates greatly, and is mainly influenced by temperature. At a given temperature air cannot contain more than a certain quantity of moisture in suspension, and when it has taken up this quantity it is said to be saturated. In general, the air contains from 50 to 75 per cent of the amount requisite for complete saturation, the average amount being about 1·46 in 100 parts. If the quantity be not within these limits, the air is either unpleasantly dry or moist.

The ammonia, which exists as carbonate, chloride, sulphate, or sulphide, is present only in very minute quantities, and does not exceed one part in a million parts of air.

In addition to these ingredients, ozone may perhaps be reckoned as a normal constituent, and spectroscopic analysis has shown that the salts of sodium are everywhere present in greater or less abundance.

SECTION II.—IMPURITIES IN AIR, AND THEIR EFFECTS ON PUBLIC HEALTH.

Preliminary Remarks.—Impurities in air may be roughly divided into suspended and gaseous matters. While the presence of suspended matters is rendered familiar to every one in the shining particles which become visible in the direct rays of the sun, the well-known demonstrations by Professor Tyndall with the

electric light have shown, perhaps more forcibly than heretofore, their almost universal diffusion. Particles of silica and silicates, of calcium carbonates and phosphates, of iron salts, and, in short, of every chemical constituent of the soil, are lifted by the winds and carried hither and thither. In inhabited places, carbon particles, hairs, fibres of cotton, wool, and other fabrics, starch-cells, etc., are found in great abundance. From the vegetable world are wafted seeds and the *debris* of vegetation, as well as spores, germs, pollen, and volatile substances. In like manner, the animal kingdom supplies germs of vibriones, bacteriæ, and monads, and particles of decayed or decaying tissues, such as epithelium and pus cells.

The numerous gaseous matters which pass into the atmosphere, and render it impure, will be more conveniently noticed in the subsequent remarks concerning overcrowding, and the injurious effects of different trades and manufactures.

But there are other organic vapours arising from the decomposition of vegetable and animal products which merit special attention, as, for example, those contained in the air of marshes and sewers. The exact chemical composition of these vapours still remains a mystery. Equally obscure too is the nature of those organic substances which constitute the specific poisons of contagious diseases. Whether they consist of inconceivably minute particles of decaying matter, or of living microscopic germs; whether, in some instances, they are conveyed by epithelium and pus cells from the diseased to the healthy, or are condensed with the watery vapour of the atmosphere, and thus disseminated;—all these are questions which have yet to be

satisfactorily answered. Certain it is, that in a large proportion of cases the atmosphere is made the vehicle of the contagium or morbific agent, whatever its nature; and hence the paramount importance of adopting such measures as will prevent contamination of the air; or at all events aid in dissipating or destroying its more noxious impurities. It is true, some of the operations of Nature are in themselves calculated to accomplish this end. Injurious gases become diffused, diluted, or decomposed; animal emanations are absorbed in the processes of vegetation; suspended matters are washed down by the rains, or fall by their own weight; while many organic substances are oxidised, and thus rendered innocuous. Were it not for these purifying agencies, which are in constant activity, sanitary measures would prove futile; and, indeed, they are only successful in so far as they approximate to the preventive and remedial means which Nature employs.

1. *Air vitiated by Respiration.*—The effete matters thrown off in respiration are carbonic acid, watery vapour, and certain undefined organic substances.

According to Dr. Carpenter, who has summarised the results obtained by various physiologists, an adult man, under ordinary circumstances, gives off 160 grs. of carbon per hour. In both sexes the amount increases up to about the thirtieth year, but beyond the eighth year the exhalation is greater in males than in females. Dr. Parkes has given the average amount of carbonic acid exhaled by an adult in the twenty-four hours as 16 cubic feet, or a little over ·6 cubic feet per hour.

The quantity of watery vapour thrown off by the skin and lungs varies according to the hygrometric

condition of the atmosphere. It has been estimated at from 25 to 40 oz. in the 24 hours, and requires, on the average, 210 cubic feet of air per hour to retain it in a state of vapour.

The organic matter given off has never been accurately determined. It has a very fœtid smell, and is but slowly oxidised. It is believed to be molecular, and may be said to hang about a room like clouds of tobacco-smoke, and, like tobacco-smoke, the odour is difficult to be got rid of, even after free ventilation has been resorted to. It darkens sulphuric acid, and decolorises solutions of potassium permanganate. When drawn through pure water it renders it very offensive. It is certainly nitrogenous, and probably in combination with water, because hygroscopic substances absorb it most readily. According to Lemaire, Trautman, and others, it contains minute cellular bodies named "putrefaction-cells," which have been found to bear a close resemblance to the so-called bacteriform puncta which Dr. Macdonald of Netley has detected in foul water. In sick-rooms it is associated with pus-cells and other emanations of disease. As much as 46 per cent of organic matter has been found in plaster taken from the walls of a hospital ward in Paris.

As the ammonia, and more especially the albuminoid, may be taken as an index of the amount of organic impurities contained in air collected at various places, the following summary of analyses, by Dr. Angus Smith, is instructive :—

Air obtained from	No. of Experiments.	Free Ammonia. Grains per Million cubic feet.	Albuminoid Ammonia. Grains per Million cubic feet.	Total Ammonia. Grains per Million cubic feet.
Innellan (on the banks of the Clyde) . . .	1	22·845	60·228	83·073
London . . .	18	26·780	65·947	92·727
Glasgow . . .	4	34·169	133·264	167·433
A bed-room . .	3	44·305	104·118	148·423
A midden . .	3	146·911	181·524	328·435

Practically speaking, the amount of organic matter in air vitiated by respiration is found to increase as the carbonic acid increases. According to Dr. Parkes it becomes distinctly perceptible to the sense of smell when the carbonic acid, in an inhabited room, amounts to ·7 per 1000 cubic feet of air—a statement which has been frequently verified by other experimenters.

Briefly, then, the changes produced in an occupied air-space by respiration and transpiration are the following:—The amount of oxygen is greatly lessened, the carbonic acid and watery vapour are largely increased, ammonia and organic matter are evolved, and suspended matter in the shape of low forms of cell-life and epithelium scales is thrown off.

The effects of breathing considerable quantities of carbonic acid in air otherwise pure have not yet been determined with sufficient accuracy. Dr. Angus Smith has found that 30 volumes per 1000 cubic feet of air produced great feebleness of the circulation, slowness of the heart's action, and quickened respiration, but he experienced no discomfort in a soda-water manufactory, where the amount was 2 per 1000 volumes. On the other hand, Pettenkofer and Voit found that no discom-

fort was experienced from long exposure when as much as 10 per 1000 volumes was present. In respired air, however, headache and vertigo are undoubtedly produced in many persons when the carbonic acid exceeds 1·5 per 1000 volumes, but probably this is as much due to the presence of organic effluvia, and the diminution in the quantity of oxygen, as to the increase in the amount of carbonic acid. Yet it must be borne in mind that even a small excess of carbonic acid interferes with healthy physiological action, inasmuch as it prevents the sufficient exhalation of the gas itself, and induces an undue accumulation of it in the blood. In like manner, the quantity of oxygen absorbed is lessened, and there is consequently a retardation of those oxidising processes which are requisite for the complete elimination of effete matters from the system. But while there is always an increase in the amount of carbonic acid, there is likewise, as already pointed out, a marked diminution in the quantity of oxygen in respired air. Thus, Dr. Angus Smith found that the percentage of oxygen in the open air of a suburb of Manchester amounted to 20·96; in a sitting room to 20·89; in the pit of a theatre, to 20·74; in the Court of Queen's Bench, to 20·65; and in the sumpt of a mine, to 20·1400. It does not follow that, because pain or discomfort is not always experienced in a vitiated atmosphere, no harm has been done. The effects may be slowly and imperceptibly cumulative, but they are none the less injurious, and they are now recognised as being amongst the most potent and widespread of all the "predisposing causes" of disease.

Speedily fatal results, arising from overcrowding and the want of fresh air, are familiar to every student of

medicine. Out of the 146 prisoners confined in the "Black-Hole of Calcutta," 123 died in one night: and it is significant that many of the survivors afterwards succumbed to "putrid fever." Nor have similar instances been wanting in this country. Of the 150 passengers that were shut up in the cabin of the Irish steamer *Londonderry*, with hatches battened down during a stormy night in 1848, 70 died before morning. No doubt, in these two catastrophes, the direct cause of death was asphyxia, but the fact that "putrid fever" attacked many of those who were carried out alive from the Black-Hole of Calcutta, showed that the fœtid exhalations to which they were exposed must have aided largely in destroying the lives of the immediate victims. Indeed, it is admitted by all physiologists that the re-breathing of fœtid matter thrown off by the skin and lungs, produces a kind of putrescence in the blood, in proportion to the amount inhaled and to the period of exposure to its influences. Of this species of poisoning, the history of the "Black Assizes," in the sixteenth, seventeenth, and eighteenth centuries, furnishes many terrible examples. Jail, or typhus, fever, according to Dr. Murchison, was frequently generated *de novo* solely in consequence of the disastrous effects of overcrowding and deficient ventilation, and the disease thus generated often spread from the court-house where the prisoners were tried, to the surrounding population. "My reader," said John Howard, "will judge of the malignity of the air in gaols, when I assure him that my clothes were, in my first journeys, so offensive, that in a post-chaise I could not bear the windows drawn up, and was therefore often obliged to travel on horseback. The leaves of my memorandum book were often so

tainted that I could not use it until after spreading it an hour or two before the fire." Even so late as 1815, Harty showed that typhus was being constantly generated in the prisons of Dublin whenever they became overcrowded with convicts prior to the periodical transportation of the accumulated numbers to a penal settlement. Or, to come to more recent times, one finds Dr. Buchanan reporting to the medical officer of the Privy Council regarding an extensive epidemic in Merthyr-Tydfil in the beginning of 1870, that it was true typhus fever, and that he referred it to overcrowding, and to want of ventilation in the houses of the poorer people.

Such are some of the more direct and palpable effects of overcrowding and deficient ventilation; but there are others, perhaps equally grave, though not so well pronounced, which cannot be overlooked. All the so called zymotic diseases, for example, are more specially fatal, and spread with the greatest virulence, in densely populated and badly ventilated districts, and it is in these "fever-nests" that epidemic diseases, which prevail during certain septic conditions of the atmosphere, are attended with the highest mortality and the greatest sick-rate.

Of other diseases developed by respired air, there can be no question that phthisis pulmonalis holds a prominent place on the list. A large mass of evidence has been collected from various sources bearing on this point, but the fact is now so fully recognised by the medical profession generally that a few instances will suffice. In the celebrated report of the Army Sanitary Commission, published in 1858, it was proved beyond all doubt that the excessive mortality

from consumption amongst soldiers, and in particular regiments, was due to overcrowding and insufficient ventilation. Previous to that inquiry, the cubic space per soldier in the barracks of the Foot Guards only amounted to 331 cubic feet, and the phthisis mortality was as high as 13·8 per 1000. In the Horse Guards, on the other hand, with a space per man of 572 cubic feet, the mortality from phthisis did not exceed 7·3 per 1000. It was found that phthisis prevailed at all stations, and in the most varied and healthy climates, the vitiated air in the barracks being the only condition common to all of them. In consequence of this excessive mortality, the Commissioners recommended that the cubic space allowed per man in barracks should be increased, and the ventilation improved, with the result that, from the time their recommendations were acted upon, the number of phthisical cases occurring at all these stations has materially diminished. Similar evidence is afforded by the statistics of the Royal Navy, and notably as regards the civil population, in the Report of the Health of Towns Commission, published in 1844. Indeed, it has been fully established that not only phthisis, but other lung affections, such as pneumonia and bronchitis, are generated to a large extent under like conditions, and the same may be said of such diseases as scrofula, and others of an adynamic type.

When air is vitiated by the exhalations of the sick, as in hospitals, there is a risk of gangrene and erysipelas spreading, especially in the surgical wards. The period of convalescence in many cases is retarded, and the mortality rate increased. Pus-cells, and putrefying particles are thrown off from purulent discharges, and

finding a suitable nidus elsewhere, may communicate a special disease, and thus act as a true contagium. The prevalence of purulent ophthalmia, under certain conditions, and the spread of lung-disease in badly ventilated ships, when the disease appeared to be propagated from person to person, can only be fully explained on some such theory as this.—(*Parkes.*)

2. *Air rendered Impure by Sewage and Cesspool Effluvia.*—Amongst the gases generated by the decomposition of fæcal matter, whether occurring in sewers or cesspools, may be enumerated, carbonic acid, nitrogen, sulphuretted hydrogen, light carburetted hydrogen, and ammonium sulphide. Dr. Letheby found that sewage-water, excluded from air, and containing 128 grs. of organic matter per gallon, yielded 1·2 cubic inches of gas per hour during a period of nine weeks. But the amount of gaseous products given off under ordinary circumstances must vary greatly, according to the dilution of the sewage, the rapidity of flow, temperature, ventilation of the sewers, etc. In comparing the results of analyses made by various chemists, it would appear that the oxygen is diminished, and the carbonic acid greatly increased, but that sulphuretted hydrogen and ammonium sulphide, when present, exist only in very small quantities. The peculiarly fœtid smell of sewage-gas is therefore owing to the presence of organic matter, whose exact chemical composition, however, has not been determined. Dr. Odling believes it to be carbo-ammoniacal. It is alkaline in reaction, and speedily decolorises solutions of potassium permanganate. According to Dr. Cunningham, it contains distinct bacteria, and other low forms of cell-life. Like other organic effluvia, it promotes the growth of fungi, infects milk, and taints meat.

It is doubtful whether the effects of sewer-air upon the health of men employed at work in sewers can be said to be very injurious. Indeed, the researches of Dr. Guy and Parent du Chatelet, at first sight, go to prove that this class of labourers enjoy a marked immunity from diseases which can be attributed to sewer-emanations; but, as has been shown by Dr. Murchison, there are several elements of error in their statistics which mar their conclusions. For example, Dr. Guy's researches were made before enteric and typhus fever were fully recognised as distinct diseases, and Parent du Chatelet's statistics were not only too scanty for a fair deduction, but the majority of the sewer-men whom he examined had been employed at that special work for only a short period. According to Dr. Murchison's experience, enteric fever is by no means uncommon among these men, and Dr. Peacock's inquiries led him to express a similar opinion. But whatever the issue of this question, it seems to be quite certain that constant exposure to sewer-gases diminishes the risk of being injured by them. A remarkable instance of this apparent immunity enjoyed by workmen, and the disastrous effects upon those whose exposure to such gases was only casual, is afforded by an event that occurred at Clapham in the autumn of 1829:—20 out of 22 boys at the same school were seized with violent vomiting, purging, prostration, and fever, within three hours. One boy had been seized with similar symptoms two days before, and died; another also succumbed. So alarming was the outbreak that poisoning was suspected, but, after careful investigation, it was found that the sole cause of disease was to be attributed to the opening of a drain at the back of the house. This

drain had been choked up for many years, and had been opened two days before the first illness occurred. The effluvia from the drain were most offensive, and the boys had watched the workmen cleaning it out; none of the workmen, however, were subsequently attacked with any of the symptoms which so seriously affected the boys.—(*Murchison.*)

While numerous other instances are recorded of the evil effects of the air of sewers, cesspits, drains, etc., in producing temporary ailments, such as nausea, vomiting, diarrhœa, and headache, the great interest which attaches to this important subject rests on the development and spread of enteric fever. Without entering at present into the discussion as to whether this fever is purely specific, or may be generated *de novo,* there can be no question that the polluted air from cesspits, drains, and sewers becomes the medium through which the disease is frequently propagated, if not engendered. The sewer-air, laden with *morbific ferments* or *contagia,* readily finds its way into houses, more especially in cold weather, on account of its greater tension, and in consequence of badly trapped or imperfectly ventilated drains. It may be inappreciable to the senses, but its baneful effects make themselves felt none the less, and frequently exhibit themselves in houses which in other respects are replete with every comfort which wealth can command. Indeed, it would appear that persons of the upper and middle ranks in towns are more liable to be attacked by enteric fever than the poorer classes, and for this reason—the houses of the former are more generally connected with sewers, and, either from structure or situation, are of higher elevation, so that the light sewer gases, in obedience to natural

laws, are more apt to accumulate in the drains of such houses, and when the drains are not efficiently trapped or ventilated, to effect an entrance into the houses themselves. Thus it happens that a system of sanitary engineering which is intended to prevent, and does prevent, the development of disease, not unfrequently furnishes the readiest means for its propagation. All this, however, could be frustrated if sewers and drains were always kept properly flushed and well ventilated.

Two other points connected with the propagation of enteric fever deserve notice: (1) it seems to be clearly established that the disease may be contracted by inhaling the effluvia from enteric stools previous to their being disposed of; and (2), that if these stools be thrown into a common privy, the disease is almost certain to be conveyed to others who frequent the privy; hence the necessity of disinfecting all discharges from the patient so soon as they are passed. (For further remarks on this subject, see Chap. XIV.)

Amongst other serious consequences of fæcal emanations, the occasional spread of cholera, and the occurrence of autumnal diarrhœa, are specially to be noted. The outbreak of cholera in the city of London Workhouse, in July 1866, was shown by Mr. Radcliffe (*Ninth Report of Medical Officer of the Privy Council*) to have taken place, in all probability, in consequence of a sudden efflux of sewer-air from a drain containing choleraic evacuations. Autumnal diarrhœa, again, is found to prevail when the season is warm and dry, and more particularly in badly-sewered districts. In speaking of this subject, Dr. Murchison says, that "circumscribed autumnal epidemics of enteric fever are often preceded by an increase of diarrhœa, and

the diarrhœa reaches its acme long before the fever does." After heavy falls of rain the sewers become well flushed, and the diarrhœa subsides. In country districts isolated outbreaks of diphtheria traceable to cesspool effluvia are not at all uncommon. In these cases it is generally found that there is a water-closet in the house which itself is badly ventilated, that the soil-pipe is never ventilated, and that the closet drain discharges into a cesspool which is completely covered up, and only cleaned out at rare intervals. The consequence is that any gases generated in the cesspool have no outlet except through the water-closet and into the house, and hence result attacks of diphtheria, ulcerated sore throat, and other badly defined ailments.

According to the evidence of Sir Henry de la Beche and Dr. Lyon Playfair, in the Second Report of the Health of Towns Commission, there are strong presumptive grounds for believing that emanations from streams polluted by fæcal matter may be injurious to the health of inhabitants living on their banks. It is stated that many of them were pale, and suffered from dyspepsia, and that cases of fever, when they occurred, were increased in severity. In other instances, however, no such effects have been traced.

When sewage matter is thrown over the ground the exhalations given off have likewise been proved to be sometimes productive of serious disease. Thus, Dr. Clouston has recorded an outbreak of dysentery among the patients in the Cumberland and Westmoreland Asylum, which he attributed to the emanations from sewage applied to the land about 300 yards from the Asylum. After this outbreak the sewage was

allowed to fall into a small stream, and for two years the asylum had been free from the disease. At the end of this period, however, the sewage was again applied to the farm, and again the dysentery appeared, although all proper precautions were taken in the way of disinfecting and in applying the sewage. It is to be noted that there was a stiff brick-clay subsoil, and doubtless this prevented the sufficient percolation of the sewage into the ground.

3. *Effluvia from decomposing Animal Matter.*—Under this heading may be included—the effluvia from decomposing carcases; the air of graveyards; and the effluvia from manure, tallow, and bone-burning manufactories.

On almost all these points the evidence is very conflicting. The preponderance of opinion, however, leaves no room for doubt that the effects of all such effluvia upon the health of the general population, when exposed to their influence, are more or less injurious; and in support of this view the following amongst many other confirmatory instances may be quoted:

(1.) The effluvia arising from the putrid remains of horses killed on the field of battle have frequently given rise to outbreaks of diarrhœa and dysentery amongst the soldiers. In the French camp, before Sebastopol, when numbers of the bodies of horses lay putrefying and unburied, the effects were so serious that the spread of typhus was supposed to be due to this cause.—(*Parkes.*)

(2.) According to the evidence summed up in the Report on Extramural Sepulture in 1850, the vapours given off from thickly crowded graveyards, if not

actually productive of disease, do certainly increase the sick and death rate of the immediate neighbourhood.

(3.) Although the health of workmen employed in manure and similar manufactories does not appear to be injured by their occupation, the occasionally disastrous effects upon others, of the effluvia given off, are well illustrated by the following case:—In 1847, many of the inmates of Christ Church Workhouse, Spitalfields, were seized with violent attacks of diarrhœa, of an enteric type. It was found that whenever the works were actively carried on, and particularly when the wind blew from that quarter, there ensued an outbreak of diarrhœa in the workhouse. In December of the following year, when cholera was spreading in the neighbourhood, sixty of the children were attacked one morning with violent diarrhœa. In consequence of this outbreak the owner of the manufactory was obliged to stop work, and the children rapidly recovered. Five months afterwards the works were resumed, and again there was a similar outbreak amongst the inmates occupying the part of the building opposite the manufactory. The works were once more discontinued, and the diarrhœa ceased.—(*Carpenter.*)

The effluvia produced in tallow-making and bone-burning, though sometimes very offensive, and therefore an undoubted nuisance in inhabited districts, do not appear to have produced any serious effects which have been recorded. Owing to their being slowly oxidised, such vapours may be detected at very long distances.—(*Parkes.*)

4. *Gases and Vapours given off by Alkali Works, Chemical Works, and Brickfields.*—(1.) The principal

gas evolved in alkali works is hydrochloric acid. Its effects on vegetation are very destructive, but with proper care in the condensation of the gas, there does not appear to be any evidence to show that works of this description are injurious to the health of those living in the neighbourhood.

(2.) From chemical works, and especially from those in which gas liquor is utilised for the production of salts of ammonia and other chemical compounds, the injurious gases evolved consist chiefly of sulphuretted hydrogen, ammonium sulphide, and traces of other ammonium compounds. The workmen employed at such works apparently enjoy good health, but when the noxious vapours are not properly consumed by being collected and passed through a furnace, there is no doubt that they do affect the health of the neighbouring inhabitants, though not to any serious extent.

(3.) The peculiarly pungent odour of brickfields can be felt at several hundred yards' distance; but though several cases are recorded, in which the existence of a nuisance was fully established, none are quoted as having proved that the health of the neighbourhood was affected.

5. *The Air of Marshes.*—This generally contains an excess of carbonic acid, light carburetted hydrogen, watery vapour, sulphuretted hydrogen, and organic effluvia. It also abounds with the *débris* of vegetable matter, infusoriæ, and insects.

The more serious and characteristic effects of marsh miasmata are intermittent and remittent fevers. Ailments, however, of a less severe nature—such as diarrhœa, dysentery, and various other gastric derangements—have been attributed to their influence; and

even when no marked signs of disease can be detected, the inhabitants of such districts often present an enfeebled and pallid appearance. The submerging of meadows, draining of lakes, and digging of canals, have all of them been followed by the development of marsh diseases, probably on account of the decomposition of vegetable matter which ensues. For the same reason, a long continuance of dry weather, followed by rains, favours the evolution of miasmata. Fortunately, in this country, marsh-diseases have become comparatively rare, though there is no doubt that in low-lying and badly-drained districts the excessive sick-rate which often prevails is in a great measure owing to atmospheric impurities of a marshy nature.

6. *Air-Impurities in certain Trades and Occupations.*—The deleterious impurities under this heading consist chiefly of mineral and organic substances, as, for example, the particles of coal-dust in the air of mines; particles of steel and grit given off in grinding; arsenical fumes, in copper-smelting; zinc fumes, in brassfounding; pearl-dust, in button-making; organic dust or fluff, in shoddy and flax mills, etc. But the whole of this part of the subject is so extensive, that only a few instances of the increased sick-rate and mortality produced by these impurities can be given here.

The habitual inhalation of coal-dust contained in the air of coal-mines results in what is called the "black-lung;" the pneumonic cells becoming gradually blocked up, so that, after death, the lung presents a peculiarly melanotic appearance. Cases of emphysema and chronic bronchitis are also very common amongst colliers, and it has been ascertained that the aggregate amount of sickness experienced by this class of workmen between the

ages of 20 and 60 amounts to 95 weeks, or 67 per cent more than the general average.—(*Wynter.*) No doubt much of the disease with which miners are liable to be attacked is to be attributed to the baneful effects of inhaling the products of combustion given off by candles, lamps, etc.; because, when mines are well ventilated, as in Durham and Northumberland, lung affections are much less frequent.

But of all unhealthy occupations that of steel-grinders is perhaps the most fatal. Steel-grinding is divided into dry, wet, and mixed; the injurious effects varying according to the amount of water used on the stone. Forks, needles, backs of scissors, etc., are all ground on the dry stone, and, accordingly, the men and boys employed at this kind of work suffer most. Dr. Hall of Sheffield has collected a large amount of information bearing upon this subject, from which the following particulars relating to the average duration of life of artisans in steel have been summarised by Dr. Wynter:—"Dry-grinders of forks, 29 years; razors, 31 years; scissors, 32 years; edge-tool and wool-shears, 32 years; spring-knives, 35 years; files, 35 years; saws, 38 years; sickles, 38 years." Fans, however, are now more commonly used than formerly, and wet-grinding is becoming more general, so that it is to be hoped the average longevity of Sheffield grinders is increasing.

In the pottery trade, the flat-pressers and scourers suffer to such an extent from the effects of the fine dust inhaled, that, according to Dr. Greenhow, almost all of them become eventually asthmatical.

Pearl-button makers, and workers in flax or shoddy mills, are all afflicted more or less with bronchial irritation, and many of them with decided lung-disease.

Cotton-weavers also suffer very much from the fine dust given off by the "sizing;" and recently an inquiry was made by Dr. Buchanan at Todmorden, which revealed the great prevalency of lung-disease, dyspepsia, and permanent epistaxis, amongst this class of operatives.

In addition to asthma and bronchitis, brassfounders are very liable to attacks of an affection called "brassfounders' ague," the characteristic symptoms of which present themselves in the following sequence: shivering, nervous depression, marked febrile disturbance, and profuse sweating. Flour millers, sweeps, and snuff-grinders, are all of them apt to suffer from various forms of asthma.

Workers in lead are apt to suffer from "drooping wrist" and lead colic; lucifer-match makers, from necrosis of the lower jaw, caused by phosphorus fumes; and workers in mercury, from mercurialism.

In the Third Report of the Medical Officer of the Privy Council, Dr. Greenhow gives the following summary of his inquiry into the excessive mortality from lung-diseases:—

"This inquiry has demonstrated that an excessive prevalence of pulmonary diseases is associated with a great variety of conditions, some of which must clearly be regarded as exciting causes of these diseases. With respect to others, it has been found impossible to obtain accurate and conclusive evidence that they produce diseases of the lungs, but there are strong grounds for supposing such to be the case. There is also a third class of conditions, on which great stress was laid by various medical practitioners, and which may perhaps be regarded as having a tendency to produce these diseases. The conclusions deducible from the inquiry

may therefore be arranged under the three following heads:—

"A. Conditions which this inquiry has shown to be direct causes of pulmonary diseases.

"B. Conditions so frequently associated with an excessive pressure of pulmonary diseases, that they may be regarded as at least indirect causes of these diseases.

"C. Conditions which, in all probability, co-operate in producing pulmonary diseases, but respecting the influence of which no conclusive evidence could be obtained."

"A. 1. Inhaling an atmosphere loaded with mechanical impurities, such as fine dust of metal, stone, clay, or of certain animal and vegetable products; soot, and particles of flax, cotton or woollen fibre, exemplified in the case of grinders of cutlery, needles, and other steel articles; miners, quarrymen, stonemasons, china-scourers, potters, turners of earthenware, makers of plaster-of-Paris moulds, hacklers of flax and Mexican fibre; sorters of wool, alpaca, and mohair; operatives employed in the manufacture of waste silk, and in the carding-rooms of cotton factories; wool-combers; workers in bone, ivory, horn, and mother-of-pearl; and makers of walking-sticks, and wooden handles for cutlery, umbrellas, and parasols.

"2. Inhaling an atmosphere containing carbonic acid or other gases unfit for respiration, or fumes arising from the combustion of gunpowder, or of charcoal, or other fuel, exemplified in the cases of miners and wool-combers.

"3. Inhaling an overheated and highly-dried atmosphere, exemplified in the cases of the flat-pressers, and some other workers in potteries.

"B. 1. Habitual exposure, during the hours of labour, to a hot and exceedingly moist atmosphere, exemplified in the cases of slip-makers in potteries and spinners of flax.

"2. Working in ill-ventilated and overheated factory-rooms, as in many manufactories of textile fabrics, in some of the decorators' rooms of potteries, in warehouses, and likewise in many establishments where young females are congregated together at work.

"3. Exposure to vicissitudes of temperature, exemplified in the cases of the operatives in several kinds of factories and workshops.

"4. A stooping or otherwise constrained posture while at work, exemplified in lace-makers, throwers of earthenware, certain classes of weavers, file-cutters, and silk-piercers.

"5. Working continuously many hours daily at a sedentary occupation, such as that of the glove-makers of Yeovil, decorators of earthenware, and welters and finishers of hosiery.

"6. Working in ill-ventilated and overcrowded rooms, as in the straw-plat and lace schools of Berkhamstead, Towcester, and Newport Pagnell, the winding rooms of Leek, and the weaving shops of Hinckley and Leicester.

"7. Residing in dwellings so constructed that the bedrooms are badly ventilated, and the cubical space per head is inadequate to the preservation of health, such as are to be found in Berkhamstead and Saffron Walden.

"C. 1. Bleakness of climate, a cold damp soil, prevalence of fogs.

"2. Marriages of consanguinity.

"3. Habitual abuse of alcoholic stimulants.
"4. Insufficiency of animal food."

Although certain parts of this summary have no immediate connection with the subject-matter in hand, it has been given *in extenso*, to show how frequently several causes of disease co-operate in producing the same pathological results, and how difficult it is to apportion to these causes their relative share in the combined effects. But, apart altogether from the unwholesome influences attaching to particular employments, the one great fact which stands forth with special prominence throughout the whole of Dr. Greenhow's inquiry (see also *Fourth Report to Privy Council*), is the fatally defective state of the ventilation, alike of cottage, workroom, and of busy factory. The mortality from lung-disease amongst male and female operatives was found to be from three to six times as great as in other districts in England; and in a very large proportion of cases the want of ventilation in dwelling-places, as well as work-places, prevailed to such an extent, that tubercular and scrofulous diseases must have resulted abundantly from this cause alone.

The medical officer of the Privy Council, in commenting on this inquiry, remarks—"One must remember that, in most cases, either the artisan's ill-ventilated work-place is also his ill-ventilated dwelling-place, or else the dwelling-place to which he goes for his rest is as ill-ventilated as the work-place which he leaves; that during a great part of the year the work-place has artificial light in it, in many cases gaslight for some hours of the day, and in some cases has its atmosphere vitiated by other products of combustion; that in factories during

winter the commonly adopted method of warming is one which in itself makes the air unpleasant, if not hurtful for breathing; and that in many branches of industry good ventilation is essential as a safeguard against evils which are special to the employment—essential for the removal of injurious dust, or for the abatement of an oppressive temperature."

In all these industrial employments it thus appears that the sick-rate and death-rate could both be very materially lessened by promoting ventilation, and by introducing some suitable appliances calculated to protect the workmen from the inhalation of fine dust or noxious fumes. But it was found that the workmen themselves often objected to any innovation which appeared to them to interfere with their more immediate comfort; and not a few of them were under the impression that the introduction of any measures tending to prolong life would be followed by such an overstocking of the labour market, that the difficulties of procuring a living would be greatly increased. That such shortsightedness will continue to exist amongst certain numbers of the artisan class is only what may be expected. Disease sets in so insidiously and progresses so slowly, the stock of health to start with seems so ample, and the individual prospect of death so remote, that sanitary rights are neglected and the wrongs quietly endured. No doubt, these wide-spread evils have been greatly mitigated of late years under the provisions of the Factory and Workshops' Acts, but even in his report for 1875, Mr. Redgrave, one of the two chief inspectors, complains that the workmen are still very careless about ventilation, and that they have a great aversion

to using respirators, even when they know that their use is a safeguard against disease.

In Germany, the whole of this subject has been very carefully studied by Dr. Hirt, to whose elaborate work, *Die Krankheiten der Arbeiter*, I would refer all who are desirous of making themselves fully acquainted with injurious trades and the diseases which they severally induce.

CHAPTER IV.

VENTILATION AND WARMING.

THESE two subjects may be conveniently treated under the following sections:—

I. The Amount of Fresh Air required.
II. The Necessary Amount of Cubic Space.
III. Natural Ventilation.
IV. Artificial Ventilation and Warming.

SECTION I.—THE AMOUNT OF FRESH AIR REQUIRED.

As the air contained in an inhabited room cannot, under the most favourable circumstances, be maintained in as pure a condition as the external air, the object of ventilation is to reduce the impurities of respiration to such an extent that continued inhalation of them will not be detrimental to health. While this can only be effected by a constant supply of fresh air, it is evident that the quantity required will very much depend on the amount of impurities which may be allowed to accumulate in respired air without proving injurious. The first point, therefore, which has to be determined, is the limit of maximum impurity consistent with the maintenance of perfect health. It has already been shown that the amount of carbonic acid in air vitiated by respiration is a tolerably reliable index to the other impurities; and hence the question resolves itself into

this,—What amount of carbonic acid shall be accepted as the standard of permissible maximum impurity? After numerous experiments, and a most extended inquiry, Dr. Parkes has given it as his opinion that, allowing ·4 volume as the average amount of carbonic acid in 1000 volumes of air, this standard ought not to exceed ·6 per 1000 volumes; because, when this ratio is exceeded, the organic impurities, as a rule, become perceptible to the senses. With a ratio of ·8, ·9, or 1 per 1000 volumes, the air smells stuffy and close, and beyond this it becomes foul and offensive.—(*Practical Hygiene.*)

Perhaps there is no class of buildings which present better opportunities for arriving at an approximate and practical solution of this problem than prisons; and it may prove of some service if I record briefly the results of some experiments which some time ago I had a share in conducting, and which are strongly corroborative of Dr. Parkes' views.—In one of the English convict prisons one-half the prisoners are kept in separate confinement, except when at exercise, the other half are confined in their cells only during the night and when at meals. The cubic space and ventilating arrangements in the part of the prison occupied by the former, were such, that the average ratio of carbonic acid, after a series of observations made at different hours of the night, was found to be ·720 per 1000 volumes; while in the part of the prison occupied by the latter, the cubic space was much smaller, and the average amount of carbonic acid was as high as 1·044 per 1000 volumes. The same number of observations were made in both parts of the prison at the same hours during the night-time, so that a strictly fair comparison could be drawn.

Now, a careful inspection of the two classes of prisoners resulted in showing that whereas the former were well nourished and healthy-looking, the latter presented a somewhat less robust and more pallid appearance; and after eliminating every source of error, this difference in appearance could only be accounted for by the difference in the amount of impurities contained in the respired air of both parts of the prison.

I have had many other opportunities of examining into this point, and would say, in general, that when the carbonic acid does not exceed ·8 per 1000 volumes, no *tangible* injurious effects upon the health can be detected; but when it reaches 1 per 1000 volumes, the cumulative effects manifest themselves in producing a pallid dyspeptic appearance, and make themselves felt, in numerous instances, in general *mal-aise* of a morning, slightly coated tongue, nasty taste in the mouth, and headache.

The desirability of adopting Dr. Parkes' estimate as the standard of maximum impurity is also borne out by the observations and experiments of such eminent authorities as Professor Pettenkofer of Munich, Dr. Angus Smith, and Dr. de Chaumont. "We all avoid," says Dr. Smith, "an atmosphere containing ·1 per cent of carbonic acid in crowded rooms; and the experience of civilised men is, that it is not only odious but unwholesome. When people speak of good ventilation, they mean, without knowing it, air with less than ·07 per cent of carbonic acid. We must not conclude that because the quantity of carbonic acid is small, the effect is small; the conclusion is rather that minute changes in the amount of this acid are indications of occurrences of the highest importance.—(*Air and Rain.*)

Assuming, then, that ·6 carbonic acid per 1000 volumes is accepted as the standard of maximum impurity, the next question comes to be—How much fresh air must be supplied per head per hour, in order that the respired air should not contain impurities in excess of this standard? It has already been stated, in the previous chapter, that an adult man exhales on the average ·6 cubic foot of carbonic acid per hour, and taking the initial carbonic acid contained in the atmosphere at the normal ratio of ·4 per 1000 volumes, the quantity of fresh air which should be supplied is found by calculation to amount to 3000 cubic feet per head per hour, in all cases in which the diffusion of the contained air is uniform. Of course, if a standard not so pure is fixed upon, the amount of fresh air required would be proportionately less. Thus, supposing the limit of maximum impurity to be ·7 carbonic acid per 1000 volumes, the amount required would be 2000 cubic feet; if ·8, 1500 cubic feet; and ·9, it would be 1200 cubic feet per head per hour. It is evident also that women and children would require a smaller supply than men, because they do not vitiate the air so rapidly.

The results obtained by actual experiment accord so closely with those which have been deduced from mathematical calculation, that some of them may be fitly quoted here. The following are given by Dr. de Chaumont (*Edin. Med. Journal,* 1867) as selections from a series of observations made at Aldershot camp:— In a room containing 18 men, with a supply of 1200 cubic feet of fresh air per head per hour, the carbonic acid was found to be ·855 per 1000 volumes; in another containing 13 men, with a supply of about 1700 cubic feet, it was ·759 per 1000 volumes; and in a

third, containing 22 men, and with a supply of about 765 cubic feet per head per hour, it amounted to 1·2 per 1000 volumes. All these observations were made at the same hour (5 A. M.), and in barrack-rooms ventilated on the plan proposed by the Barrack Commissioners in 1861, which provided that at least 1200 cubic feet of fresh air should be delivered per head per hour.

But there are other circumstances in which it is necessary to augment the delivery of fresh air in order to maintain the standard of purity. When lights are used, for example, and the products of combustion are allowed to pass into a room, a large supply is required to keep the contained air sufficiently diluted. Thus it is found that 1 cubic foot of coal gas destroys the oxygen of 8 cubic feet of air in combustion, and produces about 2 cubic feet of carbonic acid, besides other impurities. As a common gas-burner burns about 3 cubic feet of gas per hour, the importance of having these deleterious products of combustion carried off by special channels will be readily admitted.

It is evident also that the sick require a larger supply of fresh air than the healthy, for it has been found that when as much as 3500 to 3700 cubic feet have been delivered per patient per hour, hospital wards have not been free from offensive smell. Indeed, no greater proof can be afforded of the value of pure air than the excellent results obtained in surgical cases in times of war, and in medical cases when epidemics are raging, by exposing patients as much as possible to the external air.

Section II.—Cubic Space.

This should be large enough to permit the passage of 3000 cubic feet of air per head per hour, without producing perceptible draughts. If the cubic space per head is small, the renewal of air will necessarily be much more frequent than when it is large. Thus, with a space of 100 cubic feet, the contained air must be renewed thirty times per hour, in order that the standard amount be supplied; whereas, with one of 1000 cubic feet, only three renewals of air would be required. What, then, is the minimum amount of cubic space through which the standard amount of fresh air can be passed without perceptible movement? Professor Pettenkofer has answered this question experimentally, and has found that by means of artificial ventilation, and with the aid of the best mechanical contrivances, the air in a chamber of 424 cubic feet can be renewed six times per hour without creating any appreciable air-currents. No doubt, therefore, such a space as this, or one somewhat smaller, can be efficiently ventilated, provided that perfect artificial means be employed, and the air warmed, but with natural ventilation this becomes impossible. Indeed, a change of air three or four times per hour is all that can be borne in this country without discomfort, and this would require an initial air-space of 750 to 1000 cubic feet. Practically speaking, the difficulties of ventilating small spaces efficiently are due not so much to the movement of the contained air as to the relative position of the inlets, these being of necessity so near the person that the draughts which are produced become disagreeable or injurious. This is well exemplified in the case of

prisons. In hard-labour prisons, where convicts are confined in their cells only during the hours of rest, the cell-space seldom exceeds 200 cubic feet. The consequence is that in cold or inclement weather these draughts become so unpleasant that many of the prisoners block up the inlets as effectually as they can, and of course obstruct the ventilation to a serious extent. So far as my experience goes, it is difficult, even with the aid of a well-devised plan of ventilation, to supply the necessary amount of fresh air per head per hour without creating perceptible draughts occasionally, if the space be less than 600 cubic feet. I have further satisfied myself that with the same artificial appliances and arrangements, the air contained in small occupied spaces becomes much more impure than in large spaces. For example, in the experiments already alluded to in the last chapter, the cell-space in one-half the prison was 210 cubic feet, in the other half it was 614. The same means for extracting the foul air through flues leading from every cell to a foul-air extraction shaft, in which a furnace was kept burning to produce a constant draught, were common to both parts of the building. Moreover, the fresh-air inlets were more amply provided for in the small than in the large cells, and yet the average amount of carbonic acid, after a series of observations, was found to be 1·044 per 1000 volumes in the former, and only ·720 in the latter.

With a small cubic space it is impossible to obtain uniform diffusion of the contained air, if a large amount of fresh air is supplied, because between inlet and outlet a direct current is established, and a considerable quantity of air passes right through without being uti-

lised. Again, it is evident that if the ventilation is impeded or becomes arrested, impurities will collect with far greater rapidity in a small than in a large space, and this of itself is a great argument in favonr of the adoption of an ample cubic space as a basis. Dr. de Chaumont, in his remarks on this point, writes:— "Let us suppose two occupied spaces, one of 500 and the other 1000 feet, ventilated so that the ratio of carbonic acid is ·06 per cent, and that from some cause or other the ventilation is arrested in both, the condition will then be as follows:—

"1000 feet "Ratio of impurity.		"500 feet "Ratio of impurity.	
"After one hour .	·12 per cent.	"After one hour .	·18 per cent.
,, two hours .	·18 ,, ,,	,, two hours .	·30 ,, ,,
,, three ,, .	·24 ,, ,,	,, three ,, .	·42 ,, ,,
,, four ,, .	·30 ,, ,,	,, four ,, .	·54 ,, ,,
,, six ,, .	·42 ,, ,,	,, six ,, .	·78 ,, ,,
,, seven ,, .	·48 ,, ,,	,, seven ,, .	·90 ,, ,,

With ordinary means of ventilation (artificial excluded) both Dr. Parkes and Dr. de Chaumont have contended that the cubic space for a healthy adult ought at least to be 1000 feet. It is true this is very much in excess of what is generally obtained. In the crowded dwellings of the poorer classes it seldom exceeds 200 to 250 cubic feet: but then the disastrous effects declare themselves but too clearly in the increased rate of mortality. In metropolitan lodging-houses the allowance per head is as low as 240 cubic feet; and in the Dublin registered lodging-houses it is 300. The Barrack Commissioners, on the other hand, recommended a minimum space of 600 cubic feet for soldiers, insisting at the same time that

the air should be renewed at least twice every hour. "The only safe principle," they said, "in dealing with the subject is to have a large margin for contingencies; and the question really is, not whether 600 cubic feet per man be too much, but whether 600 cubic feet per man be enough for all the purposes of warming, ventilation, and comfort." Experiments that have since been made, and particularly those conducted by Dr. de Chaumont, prove most incontestibly that even this comparatively large allowance is inadequate for these purposes; but it was as much as could be obtained at the time, without putting the country to enormous expense. The Commissioners themselves observe:—"It has been said that the question of cubic space is simply a question of ventilation, but it is rather a question as to the possibility of ventilation. The more beds or encumbrances you have in a room, with a limited cubic space, the more obstruction you have to ventilation; the fewer the beds the more easy is it to ventilate the rooms. There are fewer nooks and corners, fewer surfaces opposed to the movement of the air, and less stagnation. We have been in rooms, both in barracks and hospitals, in which the atmosphere was positively offensive with the doors and windows open."

For further remarks on cubic space in hospitals, see Chapter on Hospitals.

In summing up this part of the subject, the following may be accepted as the standard conditions necessary for the requirements of *perfect* health:—

1. That the limit of maximum impurity of air vitiated by respiration ought not to exceed ·6 carbonic acid per 1000 volumes.

2. That to ensure the maintenance of this standard under ordinary circumstances, 3000 cubic feet of pure air must be supplied per head per hour.

3. That for this purpose, and with ordinary means of ventilation, a space of at least 1000 cubic feet should be allowed per head in buildings permanently occupied.

It may be objected that these conditions aim at too high a standard, and that in general they are seldom met with; but it must be remembered, as Dr. de Chaumont has so well pointed out, that they are based on a firm foundation of facts, and that, though it may not be possible to prove in all cases that bad effects result from a neglect of them, it does not follow that such bad effects may not have been produced. In a country like this, with a climate so variable, the cubic space allowance is a most important element in any scheme of ventilation. It should be ample enough to permit of a sufficient supply of fresh air without creating injurious draughts, and yet not too large to interfere with the maintenance of a sufficient and equable temperature during cold weather. Where artificial ventilation is provided, and when the fresh air can be heated before entering, it may be as low as 400 cubic feet, but even then the ventilating arrangements must be much more perfect than they usually are. In the case of healthy adults, such as soldiers and prisoners, the standard allowance may also be considerably lessened, if care be taken that the free entrance of fresh air at all hours and in sufficient quantity shall not be interfered with. Unfortunately the question of cubic space is a question of large outlay, and hence the desire to economise tends to curtail the minimum not within safe limits, but within

limits that will not be attended with glaring injurious effects.

In advocating these conditions, however, it is but right to state that the numerous experiments and weighty opinions of Dr. Angus Smith are somewhat at variance with them. In the first place, Dr. Smith's experiments only gave ·4 cubic feet of carbonic acid per hour, which would reduce the requisite amount of fresh air supply per hour to 2000 cubic feet; and, in the second place, Dr. Smith maintains that uniform diffusion of the contained air is the exception and not the rule, and in fact that it does not occur at all. With regard to the first of these points, the discrepancy between Dr. Smith's results and those of other physiologists may be reconciled on the ground that his trials were admittedly not made on large men; but with regard to the second, there still exists considerable divergence of opinion. If by uniform diffusion throughout an occupied space is meant the *exact* uniformity of the chemical composition of the air in every part, then it must be conceded that Dr. Smith is strictly correct; for so long as fresh air is entering and foul air issuing from a room, there will not only be a difference between the composition of the air in the immediate proximity of the inlets and outlets, but there will also be a difference in various parts caused by the currents, however imperceptible these may be. In small occupied spaces, such as prison cells, provided with adequate means for artificial ventilation, the amount of fresh air required to keep the carbonic acid from exceeding ·6 per 1000 volumes must obviously be much less than the amount required per head in a large room, because uniform diffusion is impossible, there being a constant movement

of the air from inlet towards outlet. But in a large space the case is different, even though the cubic space per head be not greater than that of the prison cell. The entering currents and the currents produced by inequalities of temperature are, in this instance, much more numerous, and produce a much greater mixing of the air, while the impurities given off by respiration have greater scope to be affected by the laws of gaseous diffusion. For all practical purposes, therefore, the condition of uniform diffusion, as applying to a room occupied by several persons, may be accepted as sufficiently accurate; and this being so, the standard amount of fresh air to be delivered per head per hour should, as already stated, be 3000 cubic feet. Indeed, the whole of the controversy between Dr. Angus Smith, on the one hand, and Drs. Parkes and de Chaumont on the other, regarding this point, seems to be based on a misunderstanding; each party estimated the requirements of ventilation for a single individual, but under different conditions—the former taking it for granted that the space is occupied by one, the latter that it is occupied by several.

Section III.—Natural Ventilation.

Natural ventilation is carried on by the agency of natural forces, such as gaseous diffusion and movements of air produced by inequalities of temperature.

1. *Diffusion.*—The force of gaseous diffusion, upon which the uniform constitution of the atmosphere itself depends, is manifestly inadequate as a ventilating power. It operates chiefly in producing, as has been already stated, a tolerably equal distribution of the gas-

eous products of respiration and combustion throughout the air contained in a room, but aids only to a very slight extent the removal of these impurities from the room, while it is altogether inoperative as regards the removal of organic impurities.

2. *Movements of Air produced by Inequalities of Temperature.*—As common air is subject, like other gases, to the laws of gaseous expansion, it undergoes a certain increase or diminution in bulk, according as it is heated or cooled. Warm air is, therefore, lighter than cold air, and hence a constant interchange goes on through every available opening, whenever there is any difference between the outside and inside temperature. The contained air, on being heated, expands, a portion of it escapes, and the colder outside air rushes in to establish the equilibrium. In this way a constant stream of fresh air may be made to enter a room by simply keeping the inside temperature higher than the outside. But in addition to the slighter currents, the movements of the external air, or winds, greatly assist ventilation by their perflating or aspirating action. Perflation is best exemplified in the cross-ventilation which takes place through opposite windows when opened. This is by far the readiest means which can be adopted for removing speedily and effectually aerial impurities from a room, but it cannot always be depended on, on account of the uncertainty of the rate of movement; for if the air be stagnant, there can be little or no perflation, while, on the other hand, if the rapidity of movement is great, perflation becomes insupportable in consequence of the draughts produced. A current of cold air moving at the rate of five or six feet per second becomes unbearable. In spite of this objec-

tion, however, cross-ventilation should always be provided for whenever it is practicable, and especially in large rooms, such as hospital wards.

The aspirating action of the wind produces up-currents through chimneys and air-shafts, by creating a partial vacuum in them, which is constantly being filled by the column of air from beneath. The mechanical arrangements which have been proposed or adopted to facilitate the action of these natural ventilating powers are so numerous and varied, that only a brief mention of the more important of them can be given. To utilise the perflating force of the wind, opposite windows should be made to open from the top and bottom, and to obviate the unpleasantness arising from draughts, some such arrangements as the following have been recommended:—

(1.) By having the window so constructed that the top slopes inward when it is opened, so that the entering current of air impinges against the ceiling. If the window is large, as in churches or schools, only a section of the upper part may be made to open in this way.

(2.) By substituting a glass louvre for the top centre pane.

(3.) By having some of the panes doubled; the outer with an open space at the lower edges; the inner with an open space of the same size at their upper edges. The air on entering is thus made to pass upwards between the panes.

(4.) By having some of the panes made of perforated glass, as in Pott's plan.

(5.) By raising the lower sash of the window two or three inches and filling in the opening under the bottom rail with a piece of wood as proposed by Mr.

P. H. Bird. This leaves a corresponding space between the meeting rails in the middle of the window through which the entering current of fresh air is directed towards the ceiling.

(6.) By having a part of a pane to open or shut at will by a spring arrangement, as in Boyle's ventilator.

(7.) By fixing a fine wire screen to the top of the window, which unfolds when the window is pulled down, and folds up when the window is shut. As the fine meshes of the screen are apt to become clogged up with dust, this plan is objectionable, except when the windows are of low elevation, as in attic rooms.

Other outlets and inlets may be provided by inserting perforated bricks in the walls near the ceiling. One of the best inlets is the Sheringham valve, which closes at will by a balanced weight. It slopes inwards and upwards when open, so that the entering current of air, which first passes through a perforated brick or grating, is directed towards the ceiling.

In some cases cross-ventilation can be tolerably well maintained, independently of opposite windows, by means of transverse ventilating boxes or tubes, situated at regular distances, and in close proximity to the ceiling. These boxes or tubes extend from wall to wall, and communicate with the external air at either end by air-bricks. The sides are made of perforated zinc, and there is a diaphragm in the centre of each, to prevent the wind from blowing right through. According to the direction of the wind, one-half the tube becomes an inlet for fresh air, which falls gently into the room through the perforated zinc, while the other half becomes an outlet for the vitiated air.

This plan does very well for large hospital wards

having an internal corridor running along one side. Inner rooms can also be supplied with a certain amount of cross-ventilation in the same way.

Another plan, which has been very much lauded within the past year, is that which is associated with the name of Mr. Tobin of Leeds. It consists in introducing fresh air by means of vertical tubes carried for a certain distance up the walls of the room, so as to obviate any discomfort arising from down-draught. In rooms or class-rooms with windows only on one side, this is a very convenient method of improving the ventilation. The same method of ventilating by vertical pipes is associated with the names of Shillito and Shorland of Manchester.

The aspirating power of the wind is best utilised by placing cowls on the tops of air-flues or chimneys. They should be made to rotate according to the direction of the wind by means of vanes, and in order to prevent the entrance of rain, their upper margin should always project to some extent. A very good form of cowl, and more suitable for large air-shafts, consists of a movable cylinder, shaped somewhat like a French *kepi*, with an opening in front, and surmounted by a vane, so that the front is always turned away from the wind. All cowls have to be well balanced, and so adjusted that they can rotate readily, without becoming fixed.

Louvres are sometimes used instead of cowls, but unless specially constructed, they are apt to let in the rain, and permit down-draughts. Mr. Ritchie has endeavoured to obviate these defects by providing a movable cylinder, turning with a vane inside the louvre, and with an opening in the side turned away from the wind, through which the air passes. It will be observed

that this arrangement merely places the cowl inside the louvre, and that, apart from architectural appearance, it does not possess the advantages of the cowl itself.

In several plans of natural ventilation the perflating and aspirating powers of the wind are both taken advantage of. Thus, in Mr. Sylvester's plan, which was in use fifty years ago, a large cowl surmounted the fresh air entrance shaft, and by means of a vane was always made to face the wind. The shaft itself was erected at a convenient distance from the building to be ventilated, and of a height varying according to circumstances. In this way the air, so to speak, was blown into the cowl and down the entrance-shaft into a chamber beneath the basement floor, where it could be heated if necessary. It then ascended by tubes leading to the different parts of the building, and finally passed out through a shaft or shafts projecting above the roof, and also fitted with cowls turning away from the wind, so as to act as aspirators.

By a suitable arrangement of. shafts and cowls, this mode of natural ventilation can be made to do excellent service in ships, and in buildings so constructed or situated that other ventilating means will not suffice. It was on this principle that Dr. Arnott ventilated the Field Lane Ragged School so successfully. The entrance and exit tubes were both fitted with cowls, the one set turning away from the wind, the other facing the wind. The latter also were of a higher elevation than the former, in order to increase their extractive power.

A system of natural ventilation, well suited for large rooms, and which has been highly spoken of by Mr. Robson, architect to the London School Board, is that devised by Mr. Potts. It consists of a hollow

metal cornice running continuously round the room, and divided longitudinally throughout its whole length into two separate channels, by a plate attached to the lower one. The fresh air is admitted through openings in the wall into the lower channel, and falls imperceptibly into the room through numerous perforations. The upper channel communicates either with the smoke-flue or other air-shalf, and receives the vitiated air through a series of small openings similar to those of the lower channel. As the fresh air being colder descends by its own gravity, and the vitiated air being warmer rises to the highest point, there is no doubt that the principles of the system are correct. Mr. Robson strongly recommends it for facility of application to buildings originally erected without proper provision for ventilation, for sightliness, economy of first cost, and self-acting properties.

Another plan, which has been found to work well in schools, has been proposed by Mr. H. Varley. A perforated zinc tube, communicating with the external air, passes along the cornice of three sides of the room, while on the fourth side another perforated tube is connected with the chimney, which acts as the extraction-shaft.

The plan proposed by Mr. M'Kinnell, though it belongs to the same category, is less widely applicable than either of these two, because it is only suited for one-storeyed buildings or upper rooms. It consists of two hollow cylinders, one within the other, and of such relative calibre that the transverse area between the tubes is equal to the sectional area of the inner tube. The inner tube is of slightly higher elevation than the outer, and acts as the outlet. The fresh air enters between the tubes, and is thrown up towards the ceiling by means of a horizontal flange surrounding the lower

margin of the inner tube. Both tubes should be situated in the centre of the ceiling or roof.

For ventilating workshops or factories, a plan has been advocated by Dr. Stallard, which appears to possess some special merits beyond those of mere novelty. He proposes that the ceiling of every workshop should be formed of zinc or oiled paper pierced by numerous small holes. Above this perforated ceiling, and between it and the roof, or between it and the next floor above, there should be a free space or air-chamber open to the atmosphere on all sides. This plan, while it would not interfere with ventilation by open windows nor with ordinary methods of warming, would give free play to the different modes of natural ventilation, and is intended to supply, as nearly as possible, the conditions of living in the open air, summer and winter, without exposure to extremes of weather.

Section IV.—Artificial Ventilation and Warming.

It will be convenient to consider these two subjects conjointly.

Artificial ventilation is carried on either by forcing the air into and through a room (propulsion), or by drawing the air out of a room (extraction). These two methods are also spoken of as the *plenum* and *vacuum* systems of ventilation.

Although it may appear to be an easy matter to ventilate a room without any regard to temperature, or to warm it without providing for a due supply of fresh air, it becomes a problem of very considerable difficulty to ensure in all cases that both the ventilation and

warming shall be efficient and satisfactory. This difficulty depends in a great measure on the fact that the means employed in ventilating necessarily dissipate and carry off a certain quantity of the heat which should be utilised for warming purposes.

In this country artificial ventilation and warming are usually provided for by open fire-places. The heat is obtained by radiation from the incandescent fire, and by radiation and reflection from the different parts of the grate, while ventilation is carried on by the constant current of heated air rushing up the chimney. Even when there is no fire, the chimney acts as a very efficient ventilating shaft.

When doors and windows are closed and a fire kept burning, the fresh air enters the room through every chink and opening, provided there are no special inlets. Hence it follows that the more closely doors and windows are made to fit, so much greater are the obstacles to the entrance of fresh air. When this is the case, the fire feeds itself by establishing a double current in the chimney, the downward current entering the room in puffs and carrying with it clouds of smoke. Generally, however, doors and windows are not made to fit so closely that a sufficient amount of air for feeding the fire cannot enter, and under ordinary circumstances the supply and circulation are somewhat as follows:—The greater portion of the fresh air enters beneath the door, and is drawn along the floor towards the fire-place. It is warmed to a certain extent during its course by the radiating heat of the fire, and when it approaches the fire-place, part of it rushes up the chimney along with the smoke, while the other part ascends towards the ceiling, and after ascending passes along the ceiling to-

wards the opposite end of the room. During its progress it becomes cooled, and therefore descends to be again drawn towards the fire-place with a fresh supply from beneath the door and through the chinks of the window-frames if they are not air-tight. As the air which thus enters is usually cold air, it is evident that the room is insufficiently or unequally warmed and badly ventilated. At the end of the room opposite the fire-place the temperature is below the average, and the cold current near the floor chills the feet. Moreover, the air is not properly diffused, so that although a sufficient supply may actually be entering, impurities are apt to accumulate in the centre and upper parts of the room.

The position of the fire-place is likewise a matter of considerable importance. The practice followed by most builders is to place fire-places in external walls, by which means a large amount of heat is wasted. If, on the other hand, they are grouped in the centre of the house, more heat is utilised, and greater equability of the inside temperature is maintained.

With ordinary fire-places it is found that nearly seven-eighths of the heat generated passes up the chimney, along with a quantity of air varying from 6000 to 20,000 cubic feet per hour. While, therefore, a single chimney will on the average act as an efficient ventilating shaft for a room containing from three to six or more persons, it is quite clear that by far the greatest portion of the fuel is wasted as a warming agent. The structure of the fire-place thus becomes a matter of special importance, because not only may the fuel be economised to a considerable extent, but by certain mechanical arrangements an equable temperature may be maintained and the air warmed before it enters the room.

Of the fire-places adapted to meet these requirements,

one of the best is the stove devised by Captain Douglas Galton (see figs. 1, 2, 3, and 4). It provides for an air-chamber at the back, in which the fresh air is heated

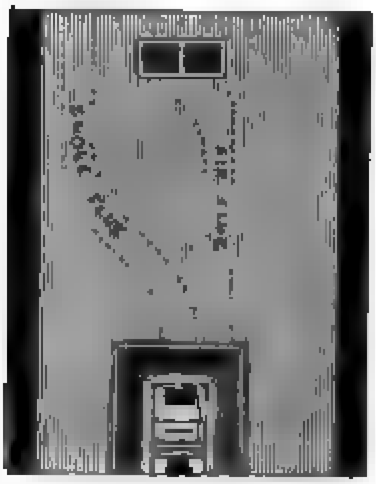

Fig. 1.—Elevation, showing air and smoke flues.

Fig. 2.—Section of grate.

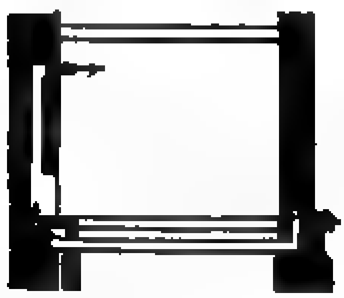

Fig. 3.—Section of a room showing air-duct and flues.

Fig. 4.—Plan of grate and air-chamber.

(After Galton.)

before it enters the room. If the fire-place be built in an external wall, the inlet for fresh air may be situated immediately behind, but if in an inner wall, a channel communicating with the external air by perforated bricks or gratings, and passing beneath the flooring or behind the skirting, must be laid. On the back of the stove broad iron flanges are cast, so as to present as large a heating surface as possible. These project backwards into the chamber, and this heating surface is

further supplemented by the smoke-flue, also of iron, which passes through the chamber, and is made continuous with the chimney. The fresh air heated in this manner enters the room by a louvred opening situated between the fire-place and ceiling, or by two such openings, one at either side of the chimney-breast. The grate itself is so constructed that the greatest amount of obtainable reflected heat is given off, and a more perfect combustion of the smoke effected than with an ordinary grate. The stoves are of different designs and sizes, to suit existing chimney-openings and different sized rooms. They have the same cheerful aspect as the ordinary grate, and produce the same degree of warmth in a room, with a third of the quantity of fuel; besides, the temperature of the room is much more equable, and unpleasant draughts of cold air are avoided. In Boyle's ventilating grates, which are perhaps more ornamental, the heated air enters the room through a transverse fenestrated opening extending along the top of the grate. Kitchen stoves have also been constructed on the same principle, and stoves suited for the centre of halls or wards. The smoke-flue of the latter is made to pass out under the flooring, and inside the fresh-air entrance channel, thus supplying a larger heating area for the entering air. The terra-cotta stoves in Herbert Hospital are of this description.

A very cheap and improved fresh-air cottage grate has been devised by Mr. Penfold of London. It is composed of well-burnt fireclay, with a chamber at the back, as in Galton's stove, in which the fresh air can be heated and discharged into adjoining rooms. This plan of supplying adjoining rooms with heated air was first introduced by Cardinal Polignac in 1713.

The people's stove, patented by Mrs. Lewis of the Strand, has also been highly spoken of. It is cheap, economical as regards fuel, free from smoke or smell, and excellently adapted for cooking purposes. In order to secure the combustion of the smoke, several grates have been invented. One of the most recent, and which has been well spoken of, is that patented by Messrs. Young Brothers of Cheapside. The coals are introduced into a trough fixed to the lower portion of the front of the grate, then, by means of a right and left handed screw worked by a ratchet-wheel, the burning fuel is raised, and the contents of the trough emptied into the cavity.

Of the numerous stoves intended to economise fuel, it will be sufficient to notice only a few of those which have been found to work more or less successfully as ventilating stoves.

1. *The Goldsworthy-Gurney Stove.*—This consists of a plain iron cylinder, surrounded by a series of upright gills or flanges, and placed in a water pan, in order that the heat rendered latent by evaporation may be carried to the distant parts of the room in the moistened currents of air which proceed in all directions from the stove. The fresh air enters through a channel opening beneath the stove, and is heated by the warm flanges surrounding it. As the water in the pan is steadily evaporated by the heat of the stove, the air in the room never becomes burnt or over-dried.

2. *Musgrave's Slow Combustion Stove.*—This resembles the Gurney stove in being surrounded by rows of flanges or ribs, but is more complicated in its internal arrangements. The receptacle for the fuel is lined with fireclay blocks, and is large enough to contain the fuel

necessary for twenty-four hours' consumption. As the fire is lighted from beneath, and the stove is charged through a sliding-door at the top, the fire may be kept burning for a whole year without requiring relighting, provided it be regularly fed and the ashes not allowed to accumulate. Before escaping through the smoke-flue, the smoke and other products of combustion are forced through two auxiliary spaces in the stove, and impart almost the whole of their heat to the stove with its appendages during their passage. The fresh air to be heated is supplied by a special channel.

3. *Pierce's Pyro-pneumatic Stove-Grate.*—In this stove the fuel is burned in an open grate, surrounded by fire-lumps, which impart their heat to the fresh air entering beneath.

4. *The Calorigen Stove,* lately invented by Mr. George, is adapted for burning gas, or as an open fire-place. The body of the stove is made of thin rolled iron, and contains a coil of wrought-iron tubing, which is open at the top of the stove, and communicates with the external air beneath. The fresh air is warmed during its passage through the coil, and enters the room at a moderate temperature. Connected with the gas stove is a cylinder placed outside the wall, and furnished with two pipes which communicate with the interior of the stove. This cylinder is open at the top, and admits the air necessary for the combustion of the gas, which is warmed to a certain extent by the products of combustion passing along the upper horizontal tube and issuing through the same opening. Waste of heat is thus prevented, and any communication between the furnace of the stove and the air of the room is avoided. In the other stove the air of the room supplies the fire.

According to Mr. Eassie, C.E., 14 lbs. of coal burned in this stove will suffice to heat a room of 15 feet square for 16 hours. There is no doubt, therefore, that the Calorigen is economical, and as it affords equable warmth with good ventilation, it has been highly commended.

The great objection to many of the commoner kinds of stoves depends on the fact that their over-heated surfaces dry the air to a very unwholesome extent, even when the fresh air is conveyed by a special entrance channel. Numbers of them, however, are put up without providing any such channel, so that the air not only becomes dry and burnt, but exceedingly close and unpleasant. Evaporating dishes placed on the stoves will assist in remedying this evil, or painting the iron surface with a solution of silica as suggested by Dr. Bond, but it is much preferable, and in the long run more economical, to have a good ventilating stove erected in the first instance.

For all ventilating stoves it is necessary that the fresh-air channels should be removed from all sources of contamination, such as drains, closets, stables, etc.; and it is advisable to protect the external openings by perforated bricks or gratings. The size of the stove, and the sectional area of the air-channel, must of course be regulated by the size of the space which is to be warmed and ventilated.

Stove smoke-flues may be either ascending or descending, but in the latter case a pilot-stove or rarefier ought to be fixed at the base of the upright chimney which receives the flue, otherwise the draught may prove faulty. Soot doors should be provided at all the bends, wherever practicable.

With the ordinary grate, the ventilation of a room may be very greatly improved by providing an entrance into the chimney near the ceiling, and to prevent reflux of smoke, the opening should be valved, as in Dr. Arnott's chimney ventilator. One or more openings for the entrance of fresh air could be obtained by inserting perforated bricks or Sheringham valves in the outer walls, also near the ceiling, but at a distance from the fire-place. Indeed the mistake which is common to the great majority of houses, consists in providing an outlet, generally the chimney, and neglecting to provide an inlet, whereas the essential principle of ventilating demands that there shall be at least two openings, one of which shall act as an inlet, and the other as an outlet, according to circumstances.

Instead of an opening leading directly into the chimney for an outlet, a much better plan is to have a flue running alongside the chimney, the entrance to the flue being situated near the ceiling. The hot air in the chimney warms the flue, and there is thus a constant upward current established without any risk of reflux of smoke. But this is an arrangement which can only be attended to in the original plan of a building; it cannot be applied as an improvement afterwards.

Some architects recommend that all the rooms in a well-constructed house should be supplied with warm air from the hall and staircase. In Mr. Ritchie's plan the air is heated to about 70° Fahr., and enters the various rooms through longitudinal openings over each door. After being diffused through the rooms it then passes up the chimneys and through flues reaching from the ceiling to the wall-heads under the roof.

Somewhat similar to this is the plan devised some

time ago by Drs. Drysdale and Hayward of Liverpool. The fresh air, warmed by a coil of hot-water pipes in the basement, is admitted into a central hall containing the staircase and separate landings, from which it enters the several rooms by suitable openings supplied by valves, and from these again it is conveyed to special outlets in the ceilings, converging to a foul-air chamber under the roof. From this foul-air chamber there is a downcast shaft communicating with the kitchen fire, which is thus made to act as an extraction furnace.

With regard to these and other complicated methods of house-ventilation, it has to be pointed out that no system is to be commended which dispenses with the opening of windows occasionally in order to secure thorough perflation. No doubt, it adds greatly to the comfort of a house if the air in the hall is warmed, and it will also add greatly to comfort if the air thus warmed can be introduced into the rooms by suitable openings over the doors; but even in winter the windows should be thrown open for a brief period at least every morning, and in summer window-ventilation should be chiefly depended on, and the entrance-hall, if louvred in the roof, would act as an extraction-shaft.

Large and compact buildings, such as hospitals, asylums, and prisons, can be very efficiently warmed and ventilated by a suitable arrangement of steam-coils or hot-water pipes. The fresh air, as it enters through openings properly distributed throughout the building, is warmed by passing over the pipes, while the vitiated air may be extracted by means of other coils of heated pipes situated in extraction-shafts.

Another mode of ventilation by extraction, and one which is frequently used in prisons, consists in having

a large foul-air extraction shaft or shafts, heated by a furnace at the bottom, and into which foul-air flues, leading from all parts of the building, are conducted. The workmanship in this case requires to be very perfect, so as to prevent any large currents of air reaching the shaft except through the flues.

By a combination of these two methods—viz. heating the fresh air before entering by hot-water pipes, and securing the removal of the vitiated air by flues leading to furnace-shafts—the largest buildings can be well warmed and ventilated. If necessary, the hot-water pipes may be made to pass through shallow basins of water, to ensure a sufficiency of moisture in the contained air.

Almost all large mines are ventilated on this principle of extraction. By means of a furnace at the bottom of the upshaft, the air is drawn down another shaft and made to traverse the various galleries by an arrangement of partitions and double doors. In well-ventilated mines as much as 2000 cubic feet of air per head per hour can be supplied in this way, and in fire-damp mines, 6000.

In men-of-war and steam-vessels an iron casing surrounding the bottom of the funnel and upper part of the boilers is utilised as an extraction shaft. When the fires are kept burning, so great is the current which rushes up this shaft, that the air can be drawn through the hatchways from all parts of the vessel, and even the hold and timbers ventilated.

In theatres, and other buildings of a similar description, the chandeliers should always be employed to extract the vitiated air. According to the experiments of General Morin, one cubic foot of gas can be utilised

so as to cause the discharge of 1000 cubic feet of air. Apart, therefore, from the great advantages arising from the direct removal of the products of combustion, the aid to ventilation furnished by the extractive power of gas-lights merits special attention, for, as a common gas-burner will burn nearly 3 feet of gas per hour, its extractive power could thus be utilised to remove nearly 3000 cubic feet of vitiated air during the same period. Where a large flood of light is required, the " sun-burner" acts very efficiently in this way, and for smaller rooms or workshops, the " box-top sun-burner " is found to answer very well. Rickett's new "ventilating globe-light" ought also to be mentioned amongst the latest improvements in this direction. It is so arranged that so soon as the gas is lighted, an upward current is produced in the main tube, and as this becomes heated, the air in the surrounding tube near the ceiling becomes rarefied and set in motion. In this way the heated air in both tubes is carried to a special shaft or to the chimney, thereby securing the removal of the products of combustion, and a steady current outwards of the vitiated air in the room. Tubes of tin or zinc placed over common burners, and communicating with the external air, or leading into the chimney, would answer the same purpose, where ornamentation can be dispensed with. Indeed, the principles of ventilation by gas-lights are in general so easy of application, and the advantages to be gained are so manifest as regards health, that it is surprising they should still be so greatly neglected.

Extraction by means of a steam jet, and extraction by a fan or screw, are now generally abandoned on the large scale. What is known as the Archimedean-screw ventilator, however, has been lately recommended for

small air-shafts, and has also been applied to large factories, where it may be worked by hand or steam power. In mines, the fan has been made to extract as much as 45,000 cubic feet of air per minute.

The system of ventilation by propulsion was first introduced by Dr. Desaguliers in 1734. It is carried on by means of a fan inclosed in a box, which can be worked by hand, horse, water, or steam power. The air enters through an opening in the centre of the box, and is thrown by the revolving fan into a conduit which communicates by proper channels with the different parts of the building. In France and America the fan is employed in the ventilation of several of the large hospitals, the air being forced into a basement chamber, where it is heated before it enters the wards. This is known as Van Hecke's system. In this country St. George's Hall, Liverpool, may be cited as affording an example of ventilation by propulsion on the large scale. The air is taken from the basement, and washed by being passed through a thin film of water thrown up by a fountain. It is then passed in cold weather into vessels for the purpose of being warmed, and in which it can be moistened by a steam jet whenever the difference between the dry and wet bulb exceeds 5°, and finally, it is propelled along different channels into the hall. In summer, the air in the conduits is cooled by the evaporation of water.

Various other methods of propulsion have been tried, such as the bellows' arrangement proposed by Dr. Hales, or the gasometer pump worked by hydraulic pressure planned by Dr. Arnott, but mostly all of them have fallen into disuse.

Concerning the relative merits of these two systems

of ventilation, viz. extraction and propulsion, the balance of evidence is most decidedly in favour of the former, as regards cost, efficiency, and stability. In either system, natural ventilation plays a most important part, whether it be taken into consideration in the construction of buildings or not; and hence every facility should be afforded for its operation, without at the same time permitting its disadvantages to take effect. For dwelling-houses, workhouses, asylums, barracks, and hospitals, there is no doubt that natural ventilation, aided by the extractive power of the heat generated in warming and lighting, is by far the best system. On the other hand, buildings such as prisons, theatres, etc., must be ventilated by mechanical appliances, and experience has proved that these should provide for ventilation by extraction.

General Considerations.—With regard to the relative position of inlets and outlets, there seems to be some difference of opinion. Theoretically, the inlets for the fresh air should be situated near the floor, and the outlets near the ceiling: but the question of temperature interferes with the practical application of this rule. If the air is not warmed before entering, the inlets should be at least 9 or 10 feet from the floor, or close to the ceiling, and so constructed that the cold air will impinge against the roof, and fall gently into the room. They should slope upwards to prevent entrance of rain, and should communicate with the external air by means of perforated bricks or gratings so as to divide the entering current and break its force. With vertical tubes such as Tobin's or Shillito's tubes, the inlets need only reach about six feet from the floor. Sliding covers, valves, or rotatory discs should also be provided, in order that

they may be partially or totally closed during rough weather. If the air is warmed before entering, the inlets may be situated, and generally are situated, near the level of the floor. But in either case it is essential that they should be equally distributed throughout the room, to ensure proper diffusion, and that the structural arrangements should permit of their being readily cleaned out, because dirt is sure to accumulate.

The outlets, as already stated, are best situated in or near the ceiling, not only because air vitiated by respiration tends to ascend on account of its lessened density, but because experiment proves that, given the same extractive power and the same size of outlet, a greater volume of air passes up a flue whose orifice is near the ceiling than up one whose orifice is near the floor. Inlets and outlets should not be situated near each other, otherwise the entering air will be extracted without being first diffused throughout the room.

Outlet tubes, or foul-air flues, as they are generally called, should be smooth, so as not to impede the current of air by friction, and in systems of ventilation by extraction, they should be air-tight. When built in external walls and only plastered, I have frequently satisfied myself by experiment that the outside air finds its way into the flue, and sometimes in such volume that though there may be a good current issuing from the top, scarcely any current can be detected entering it at the bottom. I have also found that when the wind beats strongly against the side of a building, with foul-air flues situated in the outer walls, a current of air may actually be issuing from both orifices at the same time. The experiments of Pettenkofer explain how readily such an occurrence may take place, for he

has proved beyond doubt that even under ordinary atmospheric conditions, a very considerable interchange of gases takes place through common dry-plastered walls, and indeed, as the sick often experience, very perceptible draughts find their way through outer walls when a stiff breeze is blowing. All foul-air flues, therefore, should be as nearly air-tight as possible, and if they were made of metal tubing, or of glazed earthenware, they would not only satisfy this condition, but would serve greatly to lessen the friction, which is such an impediment to ready extraction through common plastered flues. It is further evident that, when it can be avoided, they should not be situated in external walls, because in cold weather the air becomes cooled as it ascends, and unless the extractive power is very considerable, the increased weight of the column of air by loss of heat will counteract the extractive force. Where there is no system of artificial extraction, it thus often happens that outlets become inlets and inlets outlets.

Another very important point remains to be considered, namely, the sectional area of the inlets and outlets. As atmospheric conditions are constantly varying, it is obviously impossible to fix upon any size which will meet every requirement. The only alternative, therefore, is to provide an area that will suit the majority of cases, and which will be capable of being increased or diminished according to circumstances. Dr. Parkes has pointed out that in this country a size of 24 square inches for inlet per head, and the same for outlet, is the one best adapted to meet common conditions. Theoretically, the sectional area of the outlets should vary according to the height of the foul-air flues, and the Barrack Commissioners have accordingly recom-

mended that it should amount to 1 square inch for every 50 cubic feet of space for upper floors, to 1 square inch for every 55 cubic feet for rooms below, and to 1 square inch for every 60 cubic feet for rooms on the ground-floor, in buildings of three storeys. Practically, however, these nice distinctions may be disregarded, because the friction in long flues lessens very considerably the advantage in extractive power attaching to them, on account of their greater height, and also because, in the great majority of cases, the column of air in the flue increases in density the higher the flue. In prisons, where the cubic space per head is comparatively small, the sectional area of inlets and outlets should be at least 20 square inches per head. In barracks, hospitals, etc., the separate inlets should not exceed 1 square foot, otherwise the entering air will be badly distributed.

More precise details with regard to the ventilation of hospitals will be given in the chapter on hospitals.

CHAPTER V.

EXAMINATION OF AIR AND VENTILATION.

A DETAILED examination of the sufficiency of ventilation in any particular case will embrace the following inquiries:—

1. The arrangements as regards cubic space, the relative size and position of inlets and outlets, the distribution of the air, and the amount of fresh air supplied.
2. The examination of the contained air by the senses.
3. Chemical examination of the contained air.
4. Microscopical examination of suspended impurities.
5. Examination as regards temperature, moisture, etc.

SECTION I.—EXAMINATION AS REGARDS VENTILATING ARRANGEMENTS.

The measurement of the cubic space is a simple question of mensuration, but corrections must be made for furniture, bedding, etc., and for inequalities in the contour of the space to be examined. For instance, the displacement caused by solid projections into the room must be deducted, and the cubic contents of open recesses added. The allowance for each bedstead and

bedding may be estimated at 10 cubic feet, and for the space occupied by the body of each person at 3 cubic feet.

After the exact cubic space per head has been ascertained, the next points to be inquired into are the relative position and size of inlets and outlets. Perforated bricks and gratings can be approximately estimated, as regards their total open sectional area, by taking their actual superficial area, and calculating the relative size of the interstices. Inlets should be inspected as regards their freedom from accumulation of dust, etc., and outlets as regards the presence of any impediments to the ready exit of the vitiated air. Where there are open fire-places, the sectional area of the smoke flue must also be ascertained. The existence or otherwise of unpleasant draughts, and the relative position of doors and windows, and how far they assist in the ventilation of the room, are other items which must not escape notice. If the system of ventilation is artificial, it should be examined in all its details, and in this examination great assistance will be derived from inspecting the architect's plans, whenever they can be procured.

The directions of air-currents in a room can be ascertained by means of the smoke from smouldering cotton-velvet, fibres of floss-silk, small pieces of feather, small balloons filled with hydrogen gas, etc. The flame of a candle is often used for the same purpose, but it is of no value when the currents are delicate, because it is unaffected by them, but is of considerable service in showing whether air is entering or issuing through any opening. Very frequently, as has already been pointed out, openings that are meant to be inlets act as outlets,

and *vice versa*, or the movement of air in them may be unstable, intermittent, and reversed in its action, now entering and now issuing through the same opening.

All these points, and others which may arise from peculiarities of structural arrangement, must be carefully inquired into, and the various measurements and observations noted down as they are made. When the ventilation is intended to be carried on independently of open doors and windows, these should be closed during the examination.

In determining the rate of movement through the various openings, an instrument called an anemometer is generally used. This may briefly be described as a miniature windmill. The little sails, driven by the air-current, set in motion a series of small cogged wheels, which move an index or indices on a dial-plate. The velocity of the current can thus be read off for a given time, in the same way as the amount of gas which has been consumed is ascertained from a gas-meter. A very beautiful and delicate instrument of this description has been constructed by Mr. Casella, of Hatton Garden, with indices on the dial-plate indicating the velocity of an air-current in feet, hundreds of feet, thousands, etc., up to millions. By moving a catch, the machinery may be stopped at any moment of time. With this instrument, the rate of movement of air through any opening is readily, and, as a rule, accurately ascertained. Before using it, the index indicating feet in units should be set at zero, and the relative position of as many of the other indices as may be deemed necessary noted down. When the instrument is placed in the air-current, time is called, and the catch moved to set the machinery free. At the end

of one minute, two minutes, etc., according to the length of period of observation, time is again called, and the machinery immediately stopped by means of the catch, The linear dimension of the current is then read off. and if this is multiplied by the sectional area of the opening, the volume of air which has passed through in a given time can be easily calculated in cubic feet. When the instrument is placed in a tube or shaft, it should be put well in, but not quite in the centre, because the velocity of the current in the centre is greater than at the sides of the tube. Should the shaft be large, the rate of movement ought to be taken at different parts, and the average ascertained. So also, when the rate of movement is irregular, several observations should be made, and the average of the whole of them will give the approximate velocity of the current. If placed in a tube whose sectional area exceeds but very little the space occupied by the revolving sails, the results cannot be depended on; and when placed at the entrance of a tube, for example, against a perforated air-brick or grating, the velocity of the current indicated by the anemometer is considerably less than what exists in the tube. In these cases the instrument should be exactly fitted into an opening in a box, large enough to cover completely the mouth of the tube, by which means the whole of the air passing through the tube may be made to pass through the opening in the box.

The amount of air found to be issuing up chimneys or other outlets is a far more reliable index of the fresh-air supply than the amount actually ascertained to be entering through the inlets; and indeed the fresh-air supply can only be fairly estimated in this way. As already stated, the air enters through every chink and

cranny, and in dry plastered walls may enter, to no slight extent, through the walls themselves. Hence the difference between the amount of air found to be entering through the regular fresh-air inlets, and that found to be issuing through the outlets, is often very great. In a ward containing 15 beds, with one door, eight windows, and four inlets for fresh air, I have found that while only 880 cubic feet of fresh air were entering through the inlets per bed per hour, as much as 3150 were found to be issuing up the two chimneys and the three extraction-flues of the ward. During the experiments the door and windows were shut, and brisk fires kept burning in the two ventilating fire-places. The large amount, therefore, of 2270 cubic feet per bed per hour entered through chinks in the window-frames, and beneath and around the closed door. Very probably in this instance a considerable amount was also drawn, by the extractive force of the chimneys and flues, through the walls, inasmuch as they were built of brick, and were only whitewashed and not plastered.

When an examination of the respired air itself is intended, a suitable time must be selected, during which all the conditions of the efficiency of the ventilation, in any given instance, can be fairly put to the test. Take an hospital ward, for example. It is necessary that all the beds should be occupied, that windows and doors be kept shut, if ventilation is intended to be effectually carried on without them, and that an hour should be selected in the night-time when the greatest accumulation of impurities is likely to occur. Any hour between midnight and 5 A.M. would meet this condition in most cases. In order to make the examination as complete in detail as possible, it is necessary to have a wet and

dry bulb thermometer placed outside some time previously, and several others fixed at different positions in the ward. The outside and inside temperature can thus be compared, and the relative hygrometricity of the air indoors and outdoors ascertained. If the barometer is read off at the same time, and the state of the weather recorded, all the meteorological data are obtained which are usually considered necessary for a full and exhaustive report.

SECTION II.—THE EXAMINATION OF THE CONTAINED AIR BY THE SENSES.

With a little practice, this method of examination gives tolerably reliable results; but it is necessary that one should remain for some short time in the open air, before entering the ward or room to be examined, otherwise the sense of smell is likely to be blunted and unable to appreciate the degree of closeness or foulness. One of the terms, "not close," "rather close," "close," "very close," "foul," "very foul and offensive," will indicate, with sufficient accuracy, the degree of perceptible impurity in the majority of cases. The following selections from Dr. de Chaumont's experiments show how closely the sensations accord with the different degrees of impurity indicated by the percentage of carbonic acid.

At ·1408	per cent.	Extremely close and unpleasant.	At ·0843	per cent.	Not very foul.
,, ·1090	,,	Extremely close.	,, ·0804	,,	Close.
,, ·0962	,,	Very close.	,, ·0658	,,	Not very close.
,, ·0921	,,	Close.	,, ·0568	,,	Not close.

SECTION III.—CHEMICAL EXAMINATION.

1. *Carbonic Acid.*—In the chemical examination of respired air, the chief point to be determined is, the amount of carbonic acid per 1000 volumes. Pettenkofer's method is the one most generally adopted, because it is alike accurate and easy of application. For the analysis, which is volumetric, French weights and measures are used. The following apparatus and solutions are also required.

(1.) Two or more glass jars, each capable of holding 4000 to 6000 centimetre cubes, and fitted with india-rubber caps.

(2.) A Mohr's burette, graduated into centimetre cubes and tenths, fitted with pinch-cock, and large enough to hold 50 or 100 centimetre cubes.

(3.) A narrow glass measure, marked to measure 30 and 60 centimetre cubes exactly.

(4.) A pair of bellows or a bellows-pump.

(5.) Turmeric paper specially prepared. (Turmeric powder should be boiled in alcohol, and ordinary filtering paper steeped in it, then washed and dried.)

(6.) Pure clean lime water. (Both Dr. Angus Smith, and lately Pettenkofer, prefer baryta water, but I follow in my description the plan pursued by Drs. Parkes and de Chaumont, according to which my own analyses have been made.)

(7.) A solution of crystallised oxalic acid, 2·25 grammes to the litre of distilled water.

The capacity of the glass jars must be accurately determined by means of a litre measure graduated into centimetre cubes, and it is convenient to affix the cubic contents, expressed in centimetre cubes, to each. Before

being used it is necessary that the jars should be perfectly clean and dry.

The analysis depends on the relative degree of causticity of the lime water before and after it has absorbed the carbonic acid contained in the sample of air to be examined. Thus 1 cubic centimetre of the above solution of oxalic acid exactly neutralises 1 milligramme (·001 gramme) of lime; and hence the amount of lime contained in a given quantity of lime water can be readily determined by adding the solution until the point of neutralisation is reached. The amount of oxalic acid solution required for neutralisation expresses the causticity of the lime water. If now the causticity of the lime water is known before and after it has absorbed the carbonic acid in the air contained in the glass jar, the difference will give the amount of lime in milligrammes which has united with the carbonic acid, and the amount of the latter is obtained by calculating according to the atomic weights.

The amount of neutralisation is determined by means of the turmeric paper. The test solution of oxalic acid should be run into the measured quantity of lime water from the burette, and the mixture constantly stirred with a glass rod. Every now and again a small drop of the mixture is conveyed on the tip of the rod to the turmeric paper, and one can readily judge by the tint of the stain when the point of neutralisation is approached. With pure lime water the stain produced is an intense dark brown, and as the oxalic acid solution is added, it becomes gradually paler on each application, until at last the centre of the stain is not tinted, and the margin alone appears as a delicate brown ring. The solution should now be carefully added drop by drop, and when

the tint of the ring also disappears, the point of neutralisation has been reached.

In making a single analysis, it is advisable to use two jars, because otherwise a repetition of the experiment would not be possible were it required. Under ordinary circumstances, however, as many analyses can be made as there are jars used for collecting samples of the air from different parts of the same room or building. The air to be examined is forced into the jars by means of a pair of bellows, and, by a suitable arrangement of tubing connected with the bellows, it can be pumped into them from any part of the room. In the case of small occupied spaces, such as prison-cells, when it is not desirable to disturb the ventilation by opening the door, the contained air can in this way be pumped into the jars through any opening, such as the inspection hole in the door,—care being taken that the tubing and its connection with the bellows are perfectly air-tight, and that the bellows-valve acts efficiently.

Instead of bellows, a bellows-pump may be used, but in either case the nozzle should be long enough to reach the bottom of the jar. Dr. Angus Smith prefers using the bellows-pump, exhausting the air in the jar, and thus ensuring that its place shall be taken by the air to be examined. Pettenkofer and Dr. de Chaumont, on the other hand, pump the air into the jar; but either method answers very well, provided that care be taken that the jar is really filled with the air to be examined.

After the jar has been filled, 60 cubic centimetres of lime water are introduced, and the mouth of the jar closed by a tight-fitting india-rubber cap. If tubing has been used to convey the air from a distant part of the room, or from a small inhabited place without

entering it, it is necessary that this part of the experiment should be performed rapidly, in order to prevent escape by diffusion, and therefore the measured quantity of lime water should be ready to be poured into the jar whenever the nozzle of the bellows is withdrawn. The jar is then well shaken, so that the lime water is made to wash the contained air thoroughly, and afterwards is left to stand for a period of not less than six or eight hours, and not more than twenty-four. 60 cubic centimetres are introduced, in order that 30 may be taken out for analysis. So much of the lime water adheres to the sides of the jar, that the whole amount introduced cannot be poured out; and hence, if a repetition of the experiment is necessary, another jar must be used.

In making the analysis, 30 cubic centimetres of the lime water which has been employed are poured into a mixing jar, and its causticity determined as above described by the test solution. Then 30 cubic centimetres are taken from the jar, and the causticity also determined. The causticity of the lime water is found to vary from 34 to 41, according to its strength; in other words, from 34 to 41 cubic centimetres of the oxalic acid solution will be required for neutralisation, while the causticity of the lime water in the jar will be lessened in proportion to the amount of carbonic acid in the contained air. The difference between the first and second operations is doubled to account for the 30 cubic centimetres left in the jar, and the product gives the amount of lime which has combined with the carbonic acid. The amount of the latter, as already observed, is obtained by converting weight into measure according to the atomic weights, and in one sum the

factor is found to be ·39521. The capacity of the jar being known, and a deduction of 60 cubic centimetres made for the space occupied by the lime water, the amount of carbonic acid becomes a question of simple proportion. Thus, to take an example—Suppose the causticity of 30 cubic centimetres of the lime water is 39·5, and the causticity of the lime water in the jar is 33·5; suppose also that the capacity of the jar is 5060 cubic centimetres; then, to find the ratio of carbonic acid per 1000 volumes, that is per 1000 cubic centimetres, the problem is as follows:—

$(5060 - 60) : 1000 :: [(39{\cdot}5 - 33{\cdot}5) \times 2 \times {\cdot}39521] : X$

therefore $X = \frac{6 \times {\cdot}79042}{5} = {\cdot}948$ carbonic acid per 1000 volumes.

It will thus be seen that the calculations may be simplified by adopting the following rule:—Multiply the difference between the causticity of the lime water, before and after it has been placed in the jar, by 790, and divide this sum by the number of centimetre cubes contained by the jar, *minus* 60. The result will be the ratio of carbonic acid per 1000 volumes.

But a certain correction must be made for temperature, according as it is above or below the standard of 62° Fahr. As the co-efficient of expansion of air is ·0020361 for every degree Fahr., the rule for correction may be stated with sufficient accuracy thus:—For every 5° above 62° add 1 per cent to the amount of carbonic acid calculated as above, and deduct the same percentage for every 5° below 62°.

If the place of observation is much above the sea-level, a correction must also be made for the difference of atmospheric pressure. The standard barometric pressure being 30, the formula for this correction is as follows:—

30 : (observed height of barometer) : : capacity of jar : Z. The result expressed by Z is substituted for the actual capacity of the jar in the calculation for carbonic acid.

Amongst various popular tests for the estimation of the carbonic acid in air vitiated by respiration, the following, proposed by Dr. Angus Smith, is worthy of notice, because it does not require skilled manipulation, nor is it hampered with troublesome measurements or calculations. The method is based upon the fact that the amount of carbonic acid in a given quantity of air will not produce a precipitate in a certain given quantity of lime water, unless the carbonic acid is in excess. This will be better understood by comparing the different columns in the subjoined table, which is taken from Dr. Smith's work on *Air and Rain*:—

Easiest proposed Household Method.

Table.—*To be used when the point of observation is "No precipitate."* Half an ounce of lime water containing ·0195 gramme line.

Air at 0° C. and 760 Millim's bar.

Carbonic acid in the air. Per cent.	Volume of air in cubic centimetres.	Size of bottle in cubic centimetres.	Size of bottle in ounces avoirdupois.
·03	571	584	20·63
·04	428	443	15·60
·05	342	356	12·58
·06	285	299	10·57
·07	245	259	9·13
·08	214	228	8·05
·09	190	204	7·21
·10	171	185	6·54
·11	156	170	6·00
·12	143	157	5·53
·13	132	146	5·15
·14	123	137	4·82
·15	114	128	4·53
·20	86	100	3·52
·25	69	83	2·92
·30	57	71	2·51

Columns 1 and 2 give the ratio of carbonic acid in the quantity of air which will produce no precipitate in half an ounce lime water; column 3 is the same as column 2, with the addition of 14·16 cubic centimetres, or half an ounce, to give the corresponding size of bottle; and column 4 gives the size of bottle in ounces avoirdupois. It will thus be seen that different-sized bottles containing half an ounce of lime water will indicate approximately the ratio of carbonic acid in the air contained in them, by giving no precipitate when the bottle is well shaken. Thus, if a bottle of $10\frac{1}{2}$ oz. is used, and there is no precipitate, it will indicate that the ratio of carbonic acid does not exceed ·06 per cent; or if one of 8 oz. is used, and there is also no precipitate, it will indicate that the ratio does not exceed ·08, and so on. Dr. Smith says that "the lime water may be prepared of the same constant strength so closely that we may neglect the difference. Burnt lime is slaked with water and dissolved by shaking. It is then kept in a bottle to stand till it is clear. The bottle or bottles used should be wide-mouthed, so that they can be readily cleaned and dried, and the air to be examined may be made to enter them by inhaling the air contained in them through a glass or caoutchouc tube, care being taken not to breathe into the bottle."

As a practical application of this method, which can be practised by any one, Dr. Smith proposes the following rule:—"Let us keep our rooms so that the air gives no precipitate when a $10\frac{1}{2}$ oz. bottleful is shaken with half an ounce of clear lime water."

2. *Organic Impurities.*—To obtain an approximate estimate of the organic impurities, the air may be drawn through, or washed, in a very dilute solution of potas-

sium permanganate of known strength. The result is stated in the number of cubic feet of air which it takes to decolorise ·001 gramme of the potassium permanganate in solution. The method pursued by Dr. Angus Smith is somewhat different from this. He takes about 30 cubic centimetres of pure water, and adds to it a small amount of known solution of the potassium permanganate. This solution is shaken up with the air in the bottle; the air is then drawn out by a bellows-pump, and another bottleful washed, and so on until the whole colour is removed, or a sufficient amount to enable him to test the remainder, so as to be able to estimate the difference. The actual amount of oxygen taken is then calculated, and the results stated in grains per million cubic feet of air.

3. *Ammonia.*—The estimation of the ammonia, organic and albuminoid, is a still more delicate and difficult process. The water used for washing the air must be perfectly pure, and should therefore be boiled with soda or potash before distillation. From 30 to 50 cubic centimetres are then introduced into a bottle of about 2000 cubic centimetres, and the washing of successive bottlefuls of the air to be examined is continued until the water is sufficiently charged with impurities. The testing afterwards is the same as that proposed by Messrs. Wanklyn, Chapman, and Smith, for organic impurities in water, and the results are stated in grains per million cubic feet of air.

For further information concerning these methods of analysis, and for an account of numerous valuable experiments, see Dr. Angus Smith's work already quoted.

SECTION IV.—MICROSCOPICAL EXAMINATION.

Suspended matters contained in the air may be collected by drawing the air through distilled water by means of an aspirator, by washing the air in distilled water, or by employing an instrument called an aeroscope. When either of the first two processes is employed, the suspended matters are merely allowed to subside, and are then removed to a glass slip for examination. The aeroscope invented by Pouchet consists of a funnel-shaped tube, ending in a fine point, beneath which is placed a slip of glass moistened with glycerine. Both glass and tube are enclosed in an air-tight chamber, which is connected by tubing with an aspirator, so that when the stopcock of the aspirator is turned, and the water allowed to escape, the air is drawn through the tube, and impinges against the slip of glass moistened with glycerine, by which the suspended matters are arrested.

SECTION V.—EXAMINATION AS REGARDS TEMPERATURE AND MOISTURE.

1. *Temperature.*—The various points connected with the temperature of the contained air, such as its equability, sufficiency, etc., are readily ascertained by a judicious distribution of thermometers throughout the space to be examined, and by comparing the outside with the inside temperature. The efficiency of the heating apparatus is of course best tested during very cold weather and in the night time. When open fire-places are used the temperature should be noted at the remote parts of

the room, and if the air is heated before entering, it is advisable to take the temperature at the point of delivery, and to ascertain whether it is well diffused or not.

2. *Moisture.*—The amount of watery vapour, or the hygrometricity of the contained air, may be determined by hygrometers such as Daniell's and Regnault's, or by wet and dry bulb thermometers. The latter are the most convenient and reliable, but they should be distributed some two or three hours before the observations are made. The wet bulb is covered with muslin, over which there is twisted a small skein of cotton, which dips into a little vessel containing either distilled or rain water. The cotton should be boiled in ether, or soaked in a solution of sodium carbonate, to free it from fat, so that the water may readily ascend by the force of capillary attraction.

Unless the air is saturated with moisture, the temperature of the wet bulb is always below the temperature of the dry, and the number of degrees of difference between them varies according to the amount of watery vapour present. This is generally represented in relative terms. For example, the point of complete saturation being assumed to be 100, any degree of dryness may be stated as a percentage of this, and can be conveniently ascertained by reference to the following table, which has been calculated from Mr. Glashier's large tables (see Parkes' *Manual of Practical Hygiene*). The table is read by taking the temperature of the dry bulb, and the difference between it and that of the wet bulb, and noting the number given at the intersection of the two columns. This number gives the relative humidity.

 Table *of the Relative Humidity given by the difference between the Dry and Wet Bulb.*

Temperature of the Dry Bulb	Difference between the Dry and Wet Bulb															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Relative Humidity, Saturation = 100.															
90	100	95	90	85	81	77	73	69	65	62	59	56	53	50	47	44
89	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
88	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
87	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
86	100	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
85	100	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
84	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
83	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
82	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
81	100	95	90	85	80	76	72	68	64	60	56	53	50	47	44	41
80	100	95	90	85	80	75	71	67	63	59	56	53	50	47	44	41
[illegible]	100	95	[illegible]	85	80	75	71	67	63	59	56	53	50	47	44	41
78	100	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
77	100	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
76	100	94	89	84	79	75	71	67	63	59	55	52	49	46	43	40
75	100	94	89	84	79	74	70	66	62	58	55	52	49	46	43	40
74	100	94	89	84	79	74	70	66	62	58	55	52	48	45	43	40
73	100	94	89	84	79	74	70	66	62	58	54	51	48	45	42	40
72	100	94	89	84	79	74	69	65	61	57	54	51	48	45	42	39
71	100	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
70	100	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
69	100	94	88	83	78	73	68	64	60	56	53	50	47	44	41	38
68	100	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
67	100	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
66	100	94	88	83	78	73	68	64	60	56	52	48	45	42	40	37
65	100	94	88	83	78	73	68	63	59	55	51	48	45	42	39	36
64	100	94	88	82	77	72	67	63	59	55	51	48	45	42	39	36
63	100	94	88	82	77	72	67	63	59	55	51	47	44	41	38	35
62	100	94	88	82	77	72	67	62	58	55	50	47	44	41	38	35
61	100	94	88	82	77	72	67	62	58	54	50	47	44	41	38	35
60	100	94	88	82	76	71	66	62	58	54	50	46	43	40	37	34
59	100	94	88	82	76	71	66	61	57	53	49	46	43	40	37	34
58	100	93	87	81	76	71	66	61	57	53	49	46	43	40	37	34
57	100	93	87	81	75	70	65	61	57	53	49	45	42	39	36	33
56	100	93	87	81	75	70	65	60	56	52	48	44	41	[illegible]	36	32
55	100	93	87	81	75	70	65	60	56	52	48	44	41	38	35	32
54	100	93	86	80	74	69	64	59	55	51	47	43	40	37	34	31
53	100	93	86	80	74	69	64	59	55	51	47	43	39	36	33	30
52	100	93	86	80	74	69	64	59	54	50	46	42	39	36	33	30
51	100	93	86	[illegible]	74	68	63	58	54	50	46	42	38	35	32	29
50	100	93	86	80	74	68	63	58	53	49	45	41	37	34	31	29
49	100	93	86	79	73	67	62	57	53	49	45	41	37	34	31	28
48	100	93	86	79	73	67	62	57	52	48	44	40	36	33	30	
47	100	93	86	79	73	67	61	56	51	47	43	39	36	33	30	
46	100	93	86	79	73	67	61	56	51	47	43	39	35	32	29	
45	100	92	85	78	72	66	60	55	50	46	42	38	34	31	28	
44	100	92	84	78	71	65	59	54	49	45	41	37	34	31	28	
43	100	92	84	78	71	65	59	54	49	45	41	37	34	31	28	
42	100	92	84	78	71	64	59	54	49	44	40	36	34	30	27	
41	100	92	84	77	70	64	58	53	48	43	39	35	31	28		
40	100	92	84	77	69	63	57	51	46	42	38	34	31			
39	100	92	84	77	69	63	57	52	47	42	38	34				
38	100	91	83	75	68	62	56	50	45	41	37					
37	100	91	83	75	68	61	55	49	44	39						
36	100	91	82	74	66	59	53	47	42							
35	100	90	80	72												
34	100	89	79	72												
33	100	89	78	70												
32	100	87	75													

The relative humidity of the air out of doors should also be ascertained at the same time, by way of comparison.

In a room well ventilated and warmed the humidity ought to range between 73 and 75 per cent, the temperature should not fall below 60° Fahr., and the carbonic acid, as previously stated, should not exceed ·6 per 1000 volumes.

In the examination of the air contained in the crowded dwellings of the poorer classes, the senses will alone sufficiently indicate the degree of impurity, but in all cases the cubic space per head, and the means of ventilation, should be carefully noted, because otherwise any suggestions as regards improvements will at the best be haphazard, and possibly ill-advised.

CHAPTER VI.

WATER.

SECTION I.—SOURCES.

ALL supplies of fresh water are derived from the condensation of the aqueous vapour contained in the atmosphere. Whether this falls to the earth in the form of rain or snow, a certain portion of it runs off the surface and gravitates towards the sea; another portion sinks into the soil, and, passing through strata which are more or less porous, or through fissures in rocks, again reappears in springs and wells; a third portion is evaporated where it falls; and the remainder becomes absorbed in the chemical composition of minerals, or is utilised in the processes of growth and decay of animal and vegetable life.

The rainfall which flows on the surface collects in streams, lakes, and rivers, according to the conformation of the ground, while the water flowing under ground oozes to the surface either imperceptibly or in springs, and eventually unites with the surface water in its accumulation in lakes, or in its onward progress towards the sea.

The immediate sources of water-supply may therefore be classified as, rain water, and water from springs, wells, rivers, or lakes.

1. *Rain Water.*—Rain water is highly aerated, and,

when uncontaminated by the receiving surface or by air-impurities, is healthy and pleasant. But frequently, according to the analyses of the Rivers' Pollution Commissioners, it contains a large amount of organic matter, and in this country is usually far less pure than water derived from deep wells and springs. This is not to be wondered at, when we consider that the atmosphere in a thickly populated country like Great Britain becomes the recipient of vast quantities of excremental dust and effluvia, of smoke particles, and the products of animal and vegetable decay. It is, therefore, seldom stored on premises except for washing purposes, but in Venice and many other continental cities it is collected in underground reservoirs, and constitutes almost the sole source of fresh-water supply to the inhabitants. It is usually collected from the roofs of houses, and occasionally from paved or cemented ground. In hilly districts with deep ravines, it may be stored by carrying an embankment across a valley, or, in level districts, by digging a series of open trenches leading to a tank or reservoir.

The amount of water derivable from the rainfall in given cases is readily ascertained, if the mean annual rainfall of the district is known, and the dimensions of the receiving area are obtained. Thus, when the roofs of houses constitute the receiving area, the transverse section of the buildings will be one factor, and the mean annual rainfall the other. It has been estimated that the quantity which can be collected from the roof surface of any town in this country will scarcely amount to 2 gallons per inhabitant daily, assuming that the average rainfall is 20 inches, and that house accommodation gives a roof area of 60 square feet for each individual.

If lines be drawn through the sources of the tributaries of rivers marked on a map, they will be found to form the boundaries of certain areas which are called the catchment basins of the various rivers—that is the areas which receive the rainfall supplying their waters. In compact formations, where most of the rain runs off the surface, the ridge lines bounding these basins usually pass along the most elevated regions, but in porous formations their course will depend on the configuration of the retentive substratum.

The amount of rainfall which penetrates beneath the surface varies according to the density and configuration of the ground, and also depends on whatever influences the rate of evaporation. Thus, in loose sandy or gravelly districts, as much as 90 to 96 per cent sinks into the soil; in chalk districts, 42; in limestone, 20; while in districts of retentive, impermeable clay, the percentage is very small. Dr. Dalton, in his experiments on the new red sandstone soil of Manchester, found that 25 per cent of the whole rainfall penetrated to the depth of 3 feet; and Mr. Prestwich gave the amount of infiltration of the principal water-bearing strata surrounding London as varying from 48 to 60 per cent.

Other things being equal, the amount of infiltration will be far less in an undulating hilly district than in open, level plains. It is obvious also that it must vary very considerably with the season of the year. Thus, according to the experiments of Mr. Dickinson, made in the gravelly loam which covers the chalk in the valleys around Watford, it was 70 per cent in the first three months of the year; in the summer months it was only 2; while in November and December nearly the whole of the rainfall penetrated beneath the surface.

2. *Water from Wells, Springs, Rivers, and Lakes.*—The quality and composition of the water derived from these sources, depend on the nature of the soil and geological strata through which it has passed, or on the character of its surface-bed or channel. The rain, already charged with carbonic acid in its passage through the lower regions of the atmosphere, becomes still more largely impregnated with this gas when it sinks beneath the surface. In some rich soils, the amount present in the air contained within their interstices, according to Boussingault, is 250 times greater than the ordinary atmospheric ratio. Aided by the action of the carbonic acid which it has thus absorbed, the rain water dissolves and decomposes various chemical compounds which it meets with in its underground progress, and often becomes so highly charged with them as to become unfit for ordinary use, as in the case of mineral waters.

(1.) Surface or shallow well waters, though sometimes comparatively pure, frequently contain a large amount of organic matter. In mossy moorland districts, for example, or in rich vegetable soils, the water may contain from 12 to 30 grains of vegetable matter per gallon, which imparts to it a yellowish or brownish tint; while in marshy districts, the amount of organic matter varies from 10 to 100 grains. The saline constituents depend very much upon the geological character of the stratum in or upon which the well is sunk, but in inhabited places these are often masked by the products of excremental pollution. Shallow well waters are drawn from wells not more than 50 feet deep, and seldom exceeding half that depth. Surface waters from cultivated land are always more or less contaminated

with manurial impurities, and should therefore be efficiently filtered before being used.

(2.) The water from deep wells and springs varies according to the geological strata through which it passes. Thus alluvial waters are more or less impure, containing a large amount of salts (20 to 120 grains per gallon), and often much organic matter; while the chalk waters are clear, wholesome, and sparkling, holding in solution a considerable amount of calcium carbonate besides other salts, and being largely impregnated with carbonic acid. Also wholesome and agreeable to the taste, but not so suitable for cooking purposes, is the water from the limestone and magnesian limestone strata. It contains more calcium and magnesium sulphate than the chalk water, and consequently does not become so soft on boiling. Waters from the granitic, metamorphic, trap-rock, and clay-slate formations are generally very pure, and contain but small quantities of solids, consisting chiefly of sodium carbonate and chloride, with a little lime and magnesia. Waters from the millstone grit and hard oolite are also very pure. The saline constituents are by no means excessive, and are chiefly in the form of calcium and magnesium sulphate and carbonate, with traces of iron. Soft sand-rock waters, loose sand and gravel waters, and waters from the lias clays, vary very much in quality and composition, some of them being very pure, as the Farnham waters, and others containing large amounts of mineral and organic matters.

(3.) River water is in most cases softer than spring or well water. It contains a smaller amount of mineral salts, but is often largely impregnated with organic matter on account of the vegetable *débris* and animal

excreta which find their way into it. Its constant movement, however, facilitates the oxidation of organic impurities, and this purifying process is aided to some extent by the presence of fresh-water plants.

(4.) Lake water, especially in mountainous districts composed of the older rock formations, is generally very soft, containing little mineral matter; but as it is essentially a stagnant water, and as all lakes receive the washings of the districts in which they are situated, the amount of organic nitrogenous matter is sometimes very considerable. Any excess, however, of peaty matter in solution may be materially lessened by filtering through sand.

As regards the qualities of potable waters founded upon their respective sources, the following classifications are given by the Rivers' Pollution Commissioners in their Sixth Report:—

I. In respect of wholesomeness, palatability, and general fitness for drinking and cooking:—

Wholesome.	1. Spring water.	Very palatable.
	2. Deep well water.	
	3. Upland surface water.	Moderately palatable.
Suspicious.	4. Stored rain water.	
	5. Surface water from cultivated land.	Palatable.
Dangerous.	6. River water to which sewage gains access.	
	7. Shallow-well water.	

II. According to softness:—

1. Rain water.
2. Upland surface water.
3. Surface water from cultivated land.
4. Polluted river water.
5. Spring water.
6. Deep-well water.
7. Shallow-well water.

III. In respect of the influence of geological formation in rendering water sparkling, colourless, palatable, and wholesome, by percolation, the following water-bearing strata are given as the most efficient:—

1. Chalk.
2. Oolite.
3. Greensand.
4. Hastings sand.
5. New red and conglomerate sandstone.

Section II.—Quantity necessary for Health and other Purposes.

A healthy adult requires daily from 70 to 100 oz. of water for the processes of nutrition, about one-third of which is contained in articles of diet, the other two-thirds being supplied in the form of liquids. The amount for cooking has been estimated at from half-a-gallon to a gallon daily for each person, while the quantity deemed necessary for personal cleanliness and for washing purposes will necessarily vary very much according to the habits of the individual.

Dr. Parkes has given the following quantities used by a man in the middle class:—

	Gallons daily.
Cooking	·75
Fluids as drink	·33
Ablution, including a daily sponge-bath .	5
Share of utensil and house washing. .	3
Share of clothes washing . . .	3
	12·08

The soldier is allowed about 15 gallons daily, no extra allowance being given for the women and children in a regiment. In the poorer districts of the city of

London, Dr. Letheby found that the amount used was 5 gallons per individual daily, and in model lodging-houses, according to Mr. Muir, 7 gallons. In the cottages of the poor in country districts where water is scarce, the amount in many instances does not exceed 3 gallons, but then the inhabitants are not cleanly. A shower-bath daily will require 3 to 4 gallons, while a plunge-bath will take from 40 to 60 gallons. Where water-closets are used, an additional allowance of from 4 to 6 gallons must be provided. Latrines require a less amount.

In gross amounts Professor Rankine has given an estimate of 10 gallons daily per individual for domestic purposes, 10 for municipal purposes, and 10 more for trade purposes in manufacturing towns, and this amount, large though it seems, is actually supplied to many towns at the present day. Glasgow, for example, receives 35 gallons daily per head of population; Edinburgh and Southampton 35; Paris 31; and Liverpool 30. The different London water companies supply from 21 to 34 gallons, while the manufacturing towns in Lancashire and Yorkshire, according to Mr. Bateman, received from 16 to 21 gallons. Mr. Rawlinson's minimum estimate for manufacturing towns is 20 gallons per head daily, and if care be taken to prevent needless waste this amount will be quite sufficient.

In apportionating the daily allowance for all purposes, Dr. Parkes has given the following estimate:—

	Gallons per head of population.
Domestic supply	12
General baths	4
Water-closets	6
Unavoidable waste	3
Total house supply	25
Municipal purposes	5
Trade purposes	5
Total	35

No doubt this estimate may be regarded as somewhat excessive, especially in the items of domestic and water-closet supply, but it has been based on the principle that a liberal allowance is not only necessary for thorough cleanliness, but that it is also required for an efficient clearage of sewers. There can be no question, however, that the amount of water habitually wasted in many towns is enormous, reaching in all probability to at least one third of the supply, and this, when the water has to be pumped into the town, or when the town sewage has to be pumped or chemically treated in any way at the outfall, increases the rates to a very considerable extent. While part of this waste is due to underground leakage from pipes and mains, by far the larger portion of it is due to imperfect household fittings, and to carelessness in leaving stool-cocks and bib-cocks open in connection with water-closets whose flush pipes communicate directly with the mains. All closets should be provided with cisterns of the waste-preventing class, but of sufficient capacity to flush the closet-pan when used.

For hospitals the daily amount per patient may be estimated at about 30 gallons. In prisons and workhouses the quantity will vary according to the

bathing arrangements, and whether water-closets are used. In the Convict Prison, Portsmouth, where water-closets and water-latrines are both in use, and where each prisoner is allowed a general bath once a week, the amount averages about 11 gallons per convict daily.

SECTION III.—MODES OF SUPPLY.

This part of the subject has reference to wells, borings, the collection and storage of water, and to water-works generally.

1. *Wells and Borings.*—In small urban and rural districts surface wells, whether as ordinary pump wells, draw wells, or shallow dip wells, constitute the usual source of supply, and though they may naturally yield a wholesome water, the surrounding soil often becomes so saturated with impurities that it is next to impossible to prevent their pollution. In crowded localities, therefore, they should always be regarded with suspicion, and, as far as possible, their use should be discontinued. Deep wells, on the other hand, are not open to this objection, because they are generally sunk through an impervious stratum, which prevents the infiltration of any surface impurities, and at the same time serves to keep down the water in the porous strata beneath. The quality of the water from these wells, as has already been shown, will depend on the nature of the geological formation of the district. It is also apparent that, in accordance with a well-known physical law, it is only necessary to bore through the impervious stratum, and reach the water-bearing bed, for the water to rise to the surface, or to within a short distance of it, so as to be collected in a well of ordinary dimensions.

Indeed, in certain low-lying districts, where a boring is made at a point considerably below the level of the line of infiltration into the water-bearing stratum, the water rises above the surface and overflows. Such overflowing wells, or artesian wells, as they are called, were once common in the valley of the Thames, and are still to be met with in the flat lands of Essex and on the coast of Lincolnshire. Ordinary borings differ from artesian wells in not piercing through a retentive stratum in order to reach the water-supply. They are very common in the chalk and new red sandstone districts, and are made to increase the yield of the wells. Practically, it is found that one boring adds to the supply of a well nearly as much as several. Thus in the Bootle well at Liverpool, with 16 bore-holes, some of which were 600 feet deep, Mr. Stephenson found that when all were plugged up but one, the yield was 921,192 gallons per day, and when all were open it was only increased by 112,792 gallons.

Deep wells are now being abandoned for the supply of large towns, because they are found to be insufficient for the wants of a rapidly increasing population, and obviously cannot be multiplied within a given district beyond certain limits, because every single well drains a surrounding area of some considerable extent. For large isolated buildings, however, such as lunatic asylums, workhouses, and prisons, they usually supply the whole of the water required; and in selecting a site in the country for any such building, the possibility of obtaining the requisite water-supply, and the cost at which it can be procured, are points of the first importance.

Generally speaking, the chance of obtaining a good

supply will depend upon the nature of the underlying strata, and upon the level of the proposed site. Wells sunk in superficial sand or gravel beds, though yielding a good supply at ordinary times, are very liable to have their yield very much lessened in seasons of drought, unless they are situated at points considerably below the level of the surrounding country, and the same remark applies to surface wells in the chalk districts. On the other hand, deep wells or borings in the new red sandstone, and oolite or chalk formations, usually yield a large and constant supply, because these permeable rocks are so saturated with water that they may be regarded as vast subterranean reservoirs. The deepest artesian wells in the world are those at Grenelle in Paris and Kissengen in Bavaria, the former being 1800 and the latter 1878 feet in depth.

The Commissioners, in the report already alluded to, strongly urge "that preference should always be given to spring and deep well water for purely domestic purposes, over even upland surface water, not only on account of the much greater intrinsic chemical purity and palatability of these waters, but also because their physical qualities render them peculiarly valuable for domestic supply. They are almost invariably clear, colourless, transparent, and brilliant, qualities which add greatly to their acceptability as beverages; whilst their uniformity of temperature throughout the year renders them cool and refreshing in summer, and prevents them from freezing readily in winter. Such waters are of inestimable value to communities, and their conservation and utilisation are worthy of the greatest efforts of those who have the public health under their charge."

The following are some of the towns which are supplied by deep wells:—Canterbury, Cambridge, Bury St. Edmunds, and Deal, from the chalk formation; Birkenhead, Coventry, Nottingham, and Southport, from the new red sandstone; and Bedford and Scarborough from the oolite.

For a small or temporary supply the American tube well (Norton's patent) has been found to be very useful. It consists of a narrow iron tube driven into the ground in lengths, the lower part being pointed and perforated at its end, and is fitted with a single or double action pump according to the depth. The water enters the tube through the perforations, and, if the bed is sandy, has to be filtered for some time, until, by gradual removal of the sand, a well is formed around the lower end, and the water is obtained without sediment. This pump is especially adapted for country districts, and it possesses the further advantage of helping to keep out surface impurities.

In order to ascertain the yield of surface wells, the water must be pumped out, and the time noted which is required for refilling. The yield of small springs can be readily measured by receiving the water into a vessel of known dimensions, such as a cask, and also noting the time which it takes to fill.

2. *Water-Works.*—In addition to deep wells, water-works on an extensive scale obtain their supply from lakes, streams, rivers, or gathering-grounds. If from a lake of sufficient elevation above the level of the town to be supplied, the water may be distributed throughout the town in conduits and pipes by the force of gravity. When the source of supply is a stream or small river, storage works are necessary; but when the river is

large, a constant supply can be obtained at all times, independently of storage. In this case, the works required usually comprise—a weir or dam for maintaining part of the river at a nearly constant level; two or more settling-ponds, into which the water is conducted; filtering apparatus, and pumping engines.

When it is required to ascertain the yield of any small stream, it is usual to employ a weir-gauge to dam up the water into a pond behind, and allow it to flow through a sluice or over a sill of known dimensions. In the case of an average-sized stream, a rough approximation of the yield may be obtained by taking the breadth and depth at several distances in a short section of the channel which is tolerably uniform, and thus ascertaining the average sectional area. The surface-velocity may then be taken by noting the time occupied in floating a light object over the selected distance, and as four-fifths of the surface-velocity are about equal to the actual velocity, the yield in cubic feet or gallons per second can be easily calculated.

When the water-supply of a town is collected from small streams or gathering-grounds, the rainfall of the catchment basin and its available amount are items which ought to be carefully inquired into. The ratio of the available to the total rainfall, as already shown, is influenced by the nature of the soil, the steepness or flatness of the ground, the rapidity of the rainfall, and other circumstances. Professor Rankine has given the following examples:—

GROUND.	Available Rainfall divided by Total Rainfall.
Steep surfaces of granite, gneiss, and slate,	nearly 1
Moorland hilly pastures .	from ·8 to [illegible]
Flat cultivated country .	from ·5 [illegible]
Chalk	0[illegible]

The average annual rainfall in different parts of this country varies from 22 to 140 inches, the least recorded depth being 15 inches. It is greater in mountainous than in flat districts, and on the leeward side of a mountain ridge than it is on the side facing the prevailing winds. As regards water-supply, the most important data are the least annual rainfall and the longest period of drought.

In selecting drainage areas, it must be borne in mind that the nearer the actual rainfall water is collected, the freer it will be from impurities, and that purity of water and fertility of soil are not to be expected together. Water collected from a peaty soil will contain large quantities of vegetable matter, while that from a soil well cultivated will be tainted with animal impurities. The purest water, therefore, which can be collected from drainage areas is found in the barren moorland districts of the primary geological formations, or of the sandstone rocks.

The channels of the gathering-ground may either be the natural watercourses of the district, or these may be supplemented by adits, closed drains, or open ditches. The latter, however, are objectionable because they form receptacles for vegetable matter, and as the current in them must be necessarily slow, there is considerable loss by evaporation. The position, extent, and dimensions of the drains leading to the reservoir will depend upon the configuration of the district. The reservoir itself is generally a natural hollow, situated in the valley-line of the catchment basin, and of sufficient elevation to procure a fall, so that the water can be distributed without mechanical means being required to raise it. In this country the storage-room should be

large enough to contain a four or sixth months' supply; and the site which can supply the requisite storage-room with the least embankment and the least area laid under water is to be preferred.

Upon the strength and stability of the embankment everything depends. It is made water-tight by a core of clay puddle, the inner slope being protected from the action of the water by a pitching of dressed stones, and the outer, from the effects of the weather by a covering of grass sods. The puddle-core generally amounts to a tenth of the whole embankment. The height of the embankment varies from 3 to 10 feet above the highest water-level, the top being covered with broken stones. No trees or shrubs are allowed to grow upon it, and the greatest care is taken in its construction, to prevent animals, such as water-rats, burrowing into it.

Every impounding reservoir, as it is called, is provided with an overflow weir to permit the discharge of the flood supply from the drainage area, and this is often supplemented by a channel termed the *bye-wash*, which is used to divert the streams supplying the reservoir, so as to prevent fouling of the store-water. The flood-water carried off in this way flows into the natural watercourse.

In order to remove the sediment which collects in the bottom of the reservoir, there is always a cleansing pipe as well as a discharge pipe, the former being on a level with the lowest point in the reservoir, and discharging into the natural watercourse below the embankment. Both are carried through a culvert in the embankment, which is built of stone or brick, and founded on the solid rock. The aqueduct or discharge pipe bends upwards in the reservoir, and has a series

of inlets, the lowest at the lowest working level, and the whole of them guarded against the entrance of small stones, pieces of wood, or other bodies, which would interfere with the action of the valves. The sluices, which are required for both pipes, are situated in the reservoir, and are worked from the sluice-tower.

The aqueduct is that portion of the conduit leading from the reservoir to the distributing conduits. It may be open or close throughout, or partly close and partly open. If close, it generally consists of a train of cast-iron pipes securely jointed, bedded on a firm foundation, and covered to a depth of at least 2 or 3 feet, to preserve them from frost. Sluice stop-cocks are provided in the valleys, for the purpose of scouring out any stones or sediment, and, at intervals not exceeding half a mile, to permit of repairs. Valve-cocks are supplied at all the principal summits, to allow the escape of air. When the aqueduct is partly close and partly open, or if, when close, it cannot withstand the whole pressure when the demand ceases, either a system of weirs is required to discharge the surplus water, or a second store-reservoir is provided, resembling, in general plan and construction, the impounding reservoir.

The distributing conduits also consist of cast-iron pipes, and are coated, like the aqueduct pipes, with pitch, or Dr. Angus Smith's varnish, to preserve them from corrosion. The same details with regard to sluice-cocks and stop-cocks are observed in the different bends of the tracks, with this addition, that the dead ends or terminations of the branch and main conduits are supplied with scouring valves, through which stones and sediment can be washed. In wide streets, or in streets with much traffic, there is generally a service-pipe for

each side, in order that the house-pipes may be as short as possible, and may be accessible without disturbing the traffic. The house service-pipes are usually made of lead, and though they are liable to be acted upon by some waters, the readiness with which they can be adapted to all the bends and curves rendered necessary in carrying the piping to different floors of houses, gives them a preference to all other kinds of metal pipes. The waters which act most on lead are the most highly oxygenated, and those which contain organic matter; those which act least on it contain carbonic acid, calcium carbonate, and calcium phosphate. Polluted shallow well-waters are especially dangerous in this respect because they act on it violently and continuously, and hence leaden pump pipes should never be used. Various means have been proposed to protect the lead from corrosion, such as coating with bituminous pitch or with coal tar; but when the quality of the water renders lead pipes objectionable, cast and wrought iron pipes make the best substitutes, or the composite cylinder pipes manufactured by Messrs. Walker, Parker, and Co. These pipes consist of a separate tube of pure block-tin encased in lead, and the union of the two is so perfect that no amount of torsion will separate them.

As the greatest hourly demand for water is about double the average hourly demand, the main conduits supplying a town must have double the discharging capacity which would be required if the hourly demand were uniform. The additional expense in piping which would be thus entailed is sometimes so great, that distributing basins or town-reservoirs are constructed to supply certain districts. To meet all emergencies, they are made large enough to contain at least a day's supply,

and they must also have a site of sufficient elevation to ensure distribution by hydrostatic pressure. Every such reservoir should be roofed in and ventilated, to protect the water from frost and heat, and from becoming tainted with aerial impurities.

The water thus distributed to the various houses in a district is supplied either on the intermittent or constant system. The intermittent system necessitates storage in house cisterns, and is attended by so many disadvantages, that the constant system should always be adopted wherever it can be carried out. The use of cisterns, except on a small scale, for water-closets and boilers, is open to the great objection of the risk of contamination of the water, for not only are the cisterns liable to become fouled if not sufficiently protected against the entrance of aerial impurities, but the water is apt to become tainted with sewer-gases, which may enter the cistern through the overflow pipe. Moreover, in poorer districts, the cisterns are often of a very inferior description, are badly situated, and are seldom inspected or cleaned out. To meet this objection, it has been proposed to have one large tank for the supply of a group of houses,—the tank to be under the immediate inspection of the water-work officials, and to be filled daily, and the householders to be supplied through small pipes constantly charged. It is further urged against the intermittent system, that the distribution pipes, being alternately wet and dry, are liable to collect dust and the effluvia from sewers or drains. The objections to the constant system, on the other hand, are the great waste when the fittings are imperfect, and an insufficient delivery when the water-supply is not abundant. The diameters of the pipes for constant

service should therefore be carefully adapted to their discharges and to the head of pressure; the drawing taps ought to be valve-cocks to open and shut with a screw; and the town should be efficiently provided with distributing basins, so that an extra flow of water in one district would not interfere with the requisite supply of other parts. With proper fittings, strict regulations, and efficient supervision, it is now clearly established that a constant supply requires a less amount of water than an uncontrolled intermittent supply, so that even on the score of economy the constant system is to be preferred.

In order to prevent undue waste, water-meters are sometimes applied to the service-pipe supplying a group of houses, and the landlord charged for the amount used; but as this plan induces the landlord to enforce a too rigid economy, it is not to be commended. The best water-meters are capable of registering exactly all amounts exceeding a flow of one gallon per hour; but when the water contains a considerable amount of undissolved impurities, and is badly filtered, they very soon become clogged up and fail to register anything like the quantity of water which may pass through them.

The waste-preventer, or small cistern for the supply of water-closets, which has already been alluded to, should at least hold 2 gallons. The smallest waste-preventers hold $\frac{3}{4}$ of a gallon, but this quantity is insufficient to flush the pan and soil-pipe properly.

Another plan for effecting economy in the constant system, proposes that a cistern, large enough to hold a twenty-four hours' supply, be provided for each house, and that the service-pipe shall be of a diameter to

deliver the required quantity during that time, and nothing more. Every cistern supplied in this way would become gradually emptied during the day time, and would be refilled during the night; but the plan is open to the great objection attaching to the intermittent system, and does not sufficiently provide for emergencies.

Wherever cisterns are employed, they should be so situated that they can be readily cleaned out when necessary. The best materials for their construction are slate-slabs well set in cement, or galvanised iron. Leaden cisterns, unless lined with a coating of pitch, tar, or other preservative substances, are objectionable. All cisterns should be covered in, and protected from heat and frost. The inlet to every cistern ought to have a cock, with a float to rise and stop the supply when the cistern is full; and when the supply is constant, the overflow should be so arranged as to become troublesome if not immediately rectified. An overflow pipe from a cistern should never lead directly into a soil-pipe, sewer, or drain, but should end above ground over a trapped and ventilated grating. If this were always attended to, no sewer-gases could find their way to the cistern through this channel.

In addition to the arrangements for domestic supply, outlets or hydrants with valve-cocks are provided on the service-pipes of all large towns, at regular intervals, in case of fire, and for supplying water to flush the gutters and water the streets.

In laying down water-pipes and mains, it is of great importance that the separation between them and sewers, drains, or gas pipes should be as wide as possible. Whether the water-supply be on the constant or intermittent system, the risk of suction of gases or

fluids into leaky mains is imminent, though of course much less when the supply is constant. Unfortunately, however, this danger of contaminating public water supplies has hitherto not been appreciated, and indeed in many towns, as for example in Croydon, it has been enhanced by arrangements for flushing sewers directly from the mains (see Mr. Simon's *Reports*, New Series, No. VII.)

SECTION IV.—PURIFICATION OF WATER.

On an extensive scale the process of purification is carried on by means of filtration, the water being received into large filter-beds previous to its distribution. A filter-bed may be described as a tank or reservoir several feet in depth, with paved bottom, on which are laid a series of open-jointed or perforated tubular drains leading into a central culvert. The drains are covered with a layer of gravel about 3 feet deep, over which is spread a layer of sand about 2 feet deep. The layer of gravel is coarse at the bottom, becoming gradually finer towards its upper surface, and the same relative gradation, as regards coarseness and fineness, is observed with regard to the sand. The water is delivered uniformly and slowly, and in order that the filtering process may not be carried on hurriedly, the pressure is always kept low, the depth of water being seldom above 2 feet, and in some cases only 1 foot. The speed of vertical descent should not be much above 6 inches per hour, nor should the rate of filtration much exceed 700 gallons per square yard of filter-bed in the 24 hours, although some water companies filter at a much more rapid rate than this.

In large works there are always several filter-beds, to allow of some being cleansed while the others are in use. The sediment deposited on the surface of the sand requires to be scraped off at intervals, and at each cleansing operation about half-an-inch of sand is also removed. A fresh supply of sand is added when the depth of the layer is reduced to an extent which threatens to impair the efficiency of the filter. It appears that proper filtration, carried on according to this plan, removes suspended impurities, and a certain amount of dissolved mineral substances, but whether dissolved organic matters are destroyed, or oxidised to any considerable extent, seems doubtful.

Small filters for domestic use may be placed in the cistern, in the course of the delivery pipe, or they may be filled by hand. As filtering media various substances are used, such as animal or vegetable charcoal, a mixture of fine silica and charcoal, magnetic carbide of iron, sponges, wool, etc. According to Dr. Parkes, the best filters are made either of animal charcoal or magnetic carbide of iron. They are capable of removing almost all the suspended matters, and at least 40 per cent of dissolved organic impurities, together with a considerable amount of salts, such as calcium carbonate and sodium chloride. Indeed, the experiments of Mr. Wanklyn with the silicated carbon-filter prove that, by repeated filtration, river water containing a considerable amount of free and albuminoid ammonia may be made as pure as deep spring water.

Of filtering media, animal charcoal, properly washed, is now admitted to be in every way the most efficient, but it should be frequently renewed. It exerts a chemical as well as mechanical action on organic

impurities, and Dr. Frankland is so convinced of its value as a filtering agent, that he recommends its employment on a large scale for the purification of town supplies, in spite of the cost which would be entailed. Professor Bischof of Glasgow has also discovered that spongy iron possesses remarkable purifying properties, which have been fully confirmed by the experiments of the Rivers' Pollution Commissioners.

Amongst filters which have been specially commended for their efficiency, may be mentioned the cistern filter of the Water Purifying Company, London; Libscombe's Self-Cleaning Charcoal Filter; the Patent Carbon Block Filter, manufactured by Atkins and Co., London; and the Carbon Cistern Filter, planned by Mr. Finch, of the Holborn Sanitary Works. All of these contain animal charcoal as the filtering medium, and can be applied to any kind of house cistern. The filtering block of the Silicated Carbon Company consists of 75 per cent of charcoal and 22 of silica, with a little iron oxide and alumina. It is cemented into a vessel which it divides into two chambers, the one containing the filtered and the other the unfiltered water. This filter is found to work very efficiently, and with a little care retains its properties for a long time. The filtering material of the Magnetic Carbide Filter is prepared by heating hæmatite with sawdust. The only objection to it is that it sometimes communicates a slight taste of iron to the water. Another good filter is Bischof's spongy iron filter referred to above. The Patent Moulded Carbon Filter makes an elegant article for the sideboard. It consists of two glass vessels, the upper containing the filter-block, and the lower, which can be used as a water bottle, the filtered water. Tap-filters, suited for

a high or low pressure, can be fitted to the pipes themselves. They contain charcoal or silicated carbon, and would seem to act very well.

A charcoal filter has lately been introduced by Major Crease, of the Royal Marine Artillery, which, for simplicity of construction, adaptability to different kinds of water and rates of supply, and for efficiency, deserves special notice. It is now largely used in the Navy, and is specially suited for large buildings, such as asylums, workhouses, etc. The tank is made of iron, lined with cement, and the whole of the apparatus can be readily unscrewed, taken to pieces, and cleaned out when necessary, the joints being made water-tight by gutta-percha bands. Dr. Bond of Gloucester has recently devised a very cheap and efficient filter, called the Floating Syphon Filter. It consists of a hollow metallic vessel, which may be placed in a jar, tub, or other convenient vessel, and from which it will filter the water at the rate of from one to several gallons a day. The filtering material consists, for the most part, of animal charcoal. Its action is intermittent, thereby ensuring a maximum of oxidising power; it can be readily regulated and cleaned; and as any suspended impurities are kept outside the filter and allowed to gravitate towards the bottom of the containing vessel, it is not liable to become clogged up. Pocket Syphon Filters are made of hollow blocks of charcoal with a tube passing into the cavity, into which the water filters through the charcoal.

All filters after a time become clogged up, and have therefore to be taken to pieces and thoroughly cleansed; or, if this cannot be easily done, they may be purified by passing through them a solution of potassium per-

manganate or Condy's fluid, with the addition of a few drops of strong sulphuric acid, and afterwards two or three gallons of pure or distilled water, acidulated with hydrochloric acid. The charcoal in a filter may also be purified by exposing it for some time to the sun and air, or by heating it in an oven or furnace.

The purification of water without filtration is not carried on in this country on the large scale except by Dr. Clark's process. This consists in adding a certain amount of lime water to a water which contains calcium carbonate rendered soluble by the presence of carbonic acid. Spring waters in the chalk districts are all more or less "hard," and many of them contain such a large amount of calcium carbonate in solution, as to be unfit for washing purposes. Such a water, when it is to be rendered "soft" by Clark's process, is let into a tank or reservoir, where it is mixed with a proper proportion of lime water and allowed to settle, the whole of the calcium being precipitated as calcium carbonate. A perfectly clear and wholesome water is thus obtained, well suited for domestic purposes. Calcium carbonate may also be removed by boiling, in which case it is deposited as an incrustation on the inner surface of the kettle or boiler.

Aluminous salts have long been used in Eastern countries to purify water, and are found to be very efficacious in removing suspended matters, whether organic or mineral. Organic matters in solution are best treated with potassium permanganate or Condy's red fluid. It readily removes any offensive odour arising from water kept in casks, and oxidises at least a portion of the organic impurities which may be present; but as albumen is only slightly affected by it without the

aid of heat, it cannot be regarded as a reliable purifier of water tainted with animal impurities. Suspicious waters should always be boiled before being used.

Among other purifying agents may be mentioned, distillation, the exposure of water in minute divided currents to the air, the immersion of pieces of charcoal or of iron wire, and the effects of plants and fish. In store reservoirs, the presence of a moderate quantity of living plants exerts a decidedly purifying influence, while the destruction of fish has been followed by an excessive multiplication of the small crustacean animals on which the fish had lived, thereby rendering the water nauseous and impure. The remedy was found in re-stocking the reservoir with fish.—(*Rankine.*)

Section V.—Sources of Pollution.

Although reference has already been made in the preceding remarks to various ways in which drinking water becomes polluted, it will be expedient to consider this important part of the subject somewhat more fully in detail; and first with regard to the water supply of rural and small urban districts.

Estimating the town population of Great Britain at about fifteen millions, the Rivers' Pollution Commissioners observe that "the remaining twelve millions of country population derive their water almost exclusively from shallow wells, and these are, so far as our experience extends, almost always horribly polluted by sewage, and by animal matters of the most disgusting origin. The common practice in villages, and even in many small towns, is to dispose of the sewage and to provide for the water supply of each cottage, or pair of cottages, upon the premises. In the little yard or

garden attached to each tenement, or pair of tenements, two holes are dug in the porous soil; into one of these, usually the shallower of the two, all the filthy liquids of the house are discharged; from the other, which is sunk below the water line of the porous stratum, the water for drinking and other domestic uses is pumped. These two holes are not unfrequently within twelve feet of each other, and sometimes even closer. The contents of the filth hole or cesspool gradually soak away through the surrounding soil, and mingle with the water below. As the contents of the water hole or well are pumped out, they are immediately replenished from the surrounding disgusting mixture, and it is not therefore very surprising to be assured that such a well does not become dry even in summer. Unfortunately, excrementitious liquids, especially after they have soaked through a few feet of porous soil, do not impair the palatability of the water; and this polluted liquid is consumed from year to year without a suspicion of its character, until the cesspool and well receive infected sewage, and then an outbreak of epidemic disease compels attention to the polluted water. Indeed, our acquaintance with a very large proportion of this class of potable waters has been made in consequence of the occurrence of severe outbreaks of typhoid fever amongst the persons using them." (See *Sixth Report.*)

Although it can scarcely be said that this description applies to rural districts generally, there can be no doubt that it correctly represents the condition of the water supply of a vast number of villages and scattered country houses. Cesspools, cesspits, or drains, in close proximity to wells, are a fruitful source of mischief; and so also are midden-heaps or deep ash-pits connected with

privies, and the huge manure-heaps which are allowed to accumulate in farmyards. All such collections of liquid or solid filth should be regarded as dangerous nuisances, and should either be done away with altogether, or such adequate precautions taken as will obviate the risk of soakage into the well. The substitution of a dry system of conservancy and the use of pails or boxes for the cesspool, common privy, and cesspit, together with better scavenging, would lessen to a very large extent the dangers of well-pollution in country districts; but in crowded localities the soil becomes so saturated with filth of all kinds, that surface wells are never safe. All pump wells should be clay-puddled to a depth of eight or ten feet, to keep out surface impurities; and instead of draw wells or shallow open dip wells, which are especially liable to pollution, either proper pump wells should be provided, or, where the nature of the subsoil is suitable, Norton's tube wells would be found to possess many advantages. Surface wells near graveyards are very often found to be polluted.

But even when there is no drain or cesspool near, a well frequently becomes polluted because it is never cleaned out, and for my own part I regard this periodic cleansing of wells so necessary, that I think every pump well should be provided with a manhole and be cleaned out at stated times. In towns or large villages provided with a public water-supply, the closing of all surface wells, whether public or private, should be rendered compulsory; for, with drains ramifying in every direction, it may be taken for granted that they are either polluted, or are at all events constantly liable to pollution.

With regard to public supplies, it may be stated generally that water may become polluted either at its source, in the course of distribution, or through defects connected with its storage. Any supply, as for example a large part of the London supply, which is taken from a river polluted by the sewage of towns up-stream, must be carefully filtered, and even then it can only be regarded as a suspicious water. Deep wells or springs, on the other hand, may become polluted by the entrance of surface impurities, or by the access of polluted water through open fissures in the rock. But perhaps the most frequent and insidious sources of pollution to which public supplies are exposed, are those dependent upon the arrangements for distribution and storage. It has already been pointed out that with an intermittent supply the mains must necessarily become full of air when the water is turned off, and if at all leaky, as they very often are, they may become charged with liquid as well as aerial impurities. Moreover, when water-closets are served direct from the mains by mere taps or stopcocks, there is always the danger of liquid filth being sucked into them whenever a closet-pipe becomes choked up, and the pan becomes full. The following experiment will illustrate how readily such pollution may occur:—In the report on Croydon already referred to, Dr. Buchanan states that he had a common house tap connected with a pan containing solution of burnt sugar sufficient to colour some thousand gallons of water, and that in the ordinary night-intermission of supply, the whole of this was straightway sucked into the pipes, and except from one neighbour, was no more heard of. He also adds that there is an instance on record of bloody water coming

from the main tap of a house situated next to a slaughter-house. Then, too, connected with this system of intermittent supply, there are all the risks of contamination attaching to cisternage, or storage in pails, butts, or other receptacles. If the same cistern is used to supply the house and the water-closet as well, sewer-gases from the closet have access to the surface of the water in the cistern, or should the overflow-pipe from the house cistern discharge direct into a sewer or drain, there is of course the same danger. Apart also from the risk of lead-pollution from leaden cisterns, the water stored in a cistern may eventually become unfit for use, because the cistern is seldom or never cleaned out.

But even with a constant supply there appear to be certain dangers depending upon possible in-currents from leaky mains, especially when these are in juxtaposition to sewers or drains, which have hitherto escaped the notice of engineers. The physical conditions under which such in-currents may take place, have been investigated to a certain extent by Dr. Buchanan, and I quote his results here, in order that others may be induced to make experiments in the same direction. In a note appended to the Croydon report he gives the following summary of results:—"I find (1) the lateral in-current is freely produced when the water-pipe is descending, and when the pipe beyond the hole is unobstructed; (2) if the force of water-flow in a descending pipe be moderate, a moderate degree of obstruction beyond the hole does not prevent the in-current; (3) in horizontal pipes of uniform calibre, when the flow is strong, or the pipe beyohd the hole is long, or when the end of the pipe is at all

turned upwards, the in-current does not take place, but (4) momentary interference with flow *a tergo*, or momentary reduction of obstruction *a fronte*, allows of a momentary in-current through the hole; (5) in-current through a lateral hole takes place with incomparably greater ease when the hole is made at a point of constriction of the water pipe."

It has further to be observed that water-mains, if not sufficiently protected against corrosion, may render the water turbid, owing to rusting of the iron; that the tow or gaskin employed to caulk joints may taint the water for a long period if the main is several miles in length; and that leaden pipes, especially when first laid down, may become a source of danger if the water is soft.

With regard to the general effects of drinking impure water, and particular outbreaks of disease depending upon ascertained sources of pollution, see Chap. VIII.

CHAPTER VII.

WATER ANALYSIS.

SECTION I.—COLLECTION OF SAMPLES.

IN collecting water for analytical purposes, and particularly when it is intended to submit samples to a quantitative analysis, the following directions should be observed:—An ordinary glass-stoppered Winchester quart bottle will answer very well for the conveyance of the water. It should be cleaned out with strong sulphuric acid, then rinsed with ordinary good water until the rinsings are no longer acid, and finally washed out with some of the water to be examined. The bottle should be filled almost up to the neck, stoppered, and the stopper covered over with a piece of clean calico, wash leather, or gutta percha tissue, tied, and sealed. No luting should be used except sealing-wax, and even that should be dispensed with if possible. If the water contains organic matter, it should be examined at least within forty-eight hours after being collected.

In collecting pond or lake water, the bottle should be plunged into the water as far as possible from the bank, with the mouth well under the surface, so as to avoid the scum, care being taken, at the same time, that the mud at the bottom is not disturbed. If the sample is taken from a town supply, it should, if possible, be collected direct from the mains, or from the water-jets

at the cab-stands or public fountains, in which case the water should be allowed to flow for some time previous to filling the bottle. If taken from a house service-tap, the water should also be allowed to flow for some time before collecting. With regard to river water, it is recommended to select the middle of the stream, to avoid the outlets of sewers and feeders, and to note whether there has been previously a heavy fall of rain or a long drought. When a sample is required from the source of a spring, it is sometimes necessary to dig a small excavation and allow all sediment to subside before the sample is taken. Well-water should of course be drawn direct from the well.

Different methods of examination require different quantities; for Mr. Wanklyn's method one Winchester quart will be quite sufficient, but for a complete investigation some analysts require about a gallon. If a Winchester quart cannot readily be procured, a clear glass wine bottle will answer very well, but care must be taken to have it thoroughly clean, and the cork should be clean and new, and fit well.

The medical officer of health will find it very convenient to have a basket containing two or more clear glass-stoppered bottles placed under the charge of the sanitary inspector of the district. The basket should be provided with a padlock fitted with two keys, one of which should be in the possession of the medical officer of health, and the other retained by the inspector. Before forwarding the bottles, the inspector should affix a label to each, containing the date and a distinctive number, or certain particulars with regard to the source of the water and why it is suspected. For ordinary analysis pint stoppered bottles will be found to be large

enough, because, should a greater quantity be required at any time, two bottles can be used instead of one.

SECTION II.—PHYSICAL EXAMINATION.

A portion of the sample collected should be poured, after shaking the bottle, into a good-sized clear glass flask. If the flask is then held in front of a dark-coloured surface, with a good light falling on the side or from above, any suspended impurities will become visible, but care should be taken to discriminate between them and air-bubbles.

Colour and turbidity are best ascertained by pouring the water into a tall vessel of colourless glass, and placing it upon a porcelain slab or piece of white paper. Another glass of the same dimensions, filled with distilled water, should be placed by its side for comparison. Both samples are then looked through from above, and the difference between them noted. If organic matter is present, the water has usually a tinge of yellow, green, or blue, but mineral substances may give similar indications. Clay, peat, and other harmless contaminations impart a brownish tint. If the turbidity is considerable, or if the water is very dark in colour, it may be pronounced unfit for use, although filtration may render it perfectly wholesome.

To observe the smell of the water, a portion of it should be poured into a wide-mouthed flask, making it about one-third full, and then shaking it well. If the smell is unpleasant, the water is unfit to drink. Should no smell be detected, the flask should be heated, and the water again shaken, and if there is still no smell, a little caustic potash should be added to the warm

water. Any unpleasant odour which may now be given off indicates with tolerable certainty that the water contains organic impurities in considerable quantity. The occurrence of a precipitate on the addition of the caustic potash will, at the same time, indicate hardness.

With regard to taste, it is sufficient to say that a badly tasting water should be condemned for drinking purposes. Many waters, however, which are largely impregnated with dissolved animal impurities may be quite palatable.

Altogether, the physical examination of water is of a negative character; and although it may impart some useful information, it cannot be relied upon in arriving at a sound conclusion as regards the good or bad qualities of any given sample.

SECTION III.—MICROSCOPICAL EXAMINATION.

In order to collect the sediment, the water should be allowed to stand for 12 or 24 hours. Particles of sand are recognised by their angular shapes, and by their not being affected by acids. Particles of clay and marl are amorphous, and are also unaffected by acids. Particles of chalk are amorphous, and are readily dissolved by acids. Dead vegetable matter, such as woody fibre and portions of leaves, and living vegetable matter, consisting of confervoid growths, may all be detected in water which cannot be pronounced unwholesome. So also may *diatomaceæ*, *infusoria*, and *entomostraca*. Microscopical examination, therefore, is only valuable for practical purposes, in so far as it indicates the various components of the suspended matters; it gives no direct information concerning the

presence of dissolved organic impurities. There is no doubt, however, that it presents a wide and interesting field for research, and in this respect the writings of Drs. Burdon Sanderson, Cohn, and Macdonald of Netley, are extremely valuable.

SECTION IV.—CHEMICAL EXAMINATION.

This may be either qualitative or quantitative. For ordinary purposes, as, for example, in the discharge of a medical officer of health's duties in rural districts, a qualitative examination, if judiciously conducted, will be found to be quite sufficient to enable him to give a reliable opinion as to whether a water is fit for use or not in the great majority of instances. But, in all cases in which qualitative tests indicate that a water is doubtful or suspicious, and in cases which are likely to lead to magisterial proceedings, it is necessary to submit the sample to a quantitative analysis more or less complete. A quantitative analysis is also required in the examination of public supplies, and in the case of any proposed new public supply, it should be thorough in all its details.

But the main object which the sanitarian has in view is to determine whether or not any given water is dangerously contaminated with organic matter, and this, as I have already said, may be ascertained in the great majority of instances by a qualitative examination. After noting the various indications obtained from the physical examination previously described, and taking care that all test-tubes, test-glasses, measures, and the like, are thoroughly clean and conveniently arranged, the qualitative testing of one or more samples may be readily conducted as follows :—

1. *Qualitative Examination.*

(1.) *Ammonia.*—Fill an ordinary test-tube of about 1 oz. in capacity nearly full with the water to be examined, and add 3 or 4 minims of the Nessler re-agent. If a yellow or brown colour, or a brownish precipitate, be produced, the water contains ammoniacal salts. As a rule, this should be regarded as a very suspicious circumstance, and should the coloration be well marked, it is almost sufficient of itself to condemn the water for drinking purposes. A milky or curdy-looking precipitate will also indicate that the water is hard. If the precipitate is excessive, it masks, to a certain extent, the colour indicative of the test, in which case it is advisable to take a fresh sample in another test-tube, add a few drops of a strong solution of caustic potash, and after the precipitate which is thus formed subsides, add the Nessler re-agent.

(2.) *Nitrites.*—Fill an average-sized test-glass about three-parts full of the water to be examined, then add 5 minims of pure sulphuric acid and 5 minims of a solution of potassium iodide (5 grs. to 1 oz. distilled water), and afterwards pour in a small quantity of freshly-prepared starch solution. This solution is readily prepared by boiling a small quantity of starch powder in a vessel containing distilled water. A blue tint indicates nitrites, and should the colour be at all deep the water is scarcely fit to drink. As iodide of potassium sometimes contains iodate, it is always advisable to make a comparative experiment either with distilled water or with a water which is known not to contain nitrites. Instead of the sulphuric acid, acetic acid may be used, and the starch paste, potassium iodide, and acid, may be mixed before adding the solution to the water.

(3.) *Nitrates.*—The readiest method of testing for nitrates is that known as Horsley's test, of which the following modification has been proposed by Dr. Bond of Gloucester:—Put 20 minims of pure sulphuric acid into a very small test-tube, then add 10 minims of the water to be examined, and afterwards drop in carefully 1 drop of a solution of pyro-gallic acid (10 grs to 1 oz. distilled water acidulated with 2 drops of sulphuric acid). A pink zone, or sometimes a delicate blue zone changing into a dark amethyst tint, and from that into a brown tint, indicates nitrates. When shaken up, the greater part of this colouration may disappear for a time, but it gradually returns, and after the mixture has stood for a few hours, a permanent tint is developed.

The detection of nitrates in a water derived from a deep well is no evidence of sewage contamination, because as in the chalk formation, they may be derived from the strata through which the water passes, but in surface or shallow well waters, their presence may fairly be regarded as a suspicious circumstance.

(4.) *Chlorides.*—The amount of chlorine in water can be determined so quickly by a simple volumetric method which will be subsequently described, that those who are provided with the test-solution of nitrate of silver should always adopt this method; but to those who have not this test-solution the following method is recommended:—Acidulate a little of the water in a test-glass with a few drops of dilute nitric acid, and add in excess a solution of nitrate of silver. Four grains per gallon of sodium chloride give a turbidity; 10 grains, a slight precipitate; and 20 grains, a considerable precipitate, soluble in ammonia. A good water should only yield a slight haziness. If there is a distinct precipitate, it shows that the water is

derived from a formation rich in salt, such as the new red sandstone, that it is brackish if on the sea-coast, or that it has been contaminated with sewage. In the first two cases there will be a large amount of mineral solids, and therefore, in the case of a soft water, any excess of chlorides would point to sewage contamination. On the other hand, it is important to note that the absence of chlorides from a sample of water renders it very probable that it is free from sewage contamination.

(5.) *Lead and Iron.*—Boil between 3 and 4 oz. of the water acidulated with a few drops of sulphuric acid, and afterwards add sulphuretted hydrogen water. If a brown or blackish coloration is produced, the presence of lead may be inferred. If no colour can be detected, add a little potash or ammonia, and if this produces a blackish precipitate, iron is almost certain to be present. Small traces of iron in a water cannot be considered injurious, but the presence of lead is sufficient to condemn the water as unfit for use.

(6.) *Organic Matter.*—Although the permanganate of potash test has of late years fallen into disfavour with many analysts on account of its indefinitiveness, I am still of opinion that it may be employed with considerable advantage in the qualitative examination of surface well waters, and particularly in localities where salts of iron are not usually found. The following is a convenient method of applying the test:—Fill a tall colourless glass vessel or test-tube nearly full with the water to be examined, and add as much solution of potassium permanganate (2 grs. to 4 oz. distilled water) as will impart a distinct pink tinge after stirring with a glass rod. Then fill another glass cylinder or test-tube of the same size with distilled

water, and add the same quantity of permanganate solution. Place the two glasses side by side on a white sheet of paper or porcelain slab, and note any differences between the two tints which may speedily or subsequently take place. If decoloration takes place rapidly or sets in gradually, it shows that the water contains oxidisable organic matter, iron, nitrites, or sulphuretted hydrogen. The last of these is rarely found, and would be distinguished by the smell, while the presence of iron or nitrites can be ascertained by tests already described. In the absence of these three, any rapid decoloration indicates that the organic matter is of animal origin, whereas slower changes indicate that vegetable matter is present. With these limitations, and with a general knowledge of the geological characteristics of the well waters of a district, the test may be advantageously employed as a confirmatory test, though it cannot always be relied on when it gives negative results.

By a judicious application of some or all of these tests, the medical officer of health can examine several samples of water in a comparatively short space of time; but in order to conduct the examination systematically he ought to arrange the test tubes or glasses in separate sets and number them according to the samples. These, it is presumed, are all derived from surface or shallow well waters, and the following indications will enable him to decide as to whether the water is fit for use or not, or whether it is of doubtful purity, in which case it should be submitted to a quantitative analysis:—

If a water contains a considerable amount of sediment, and is found when decanted off or filtered to show little or no traces of ammonia, nitrites, or

chlorides, it shows that it is fit for use, but the well requires cleaning out; or should the well be a tube well, that it ought to be filtered. If the sediment is flocculent and dirty-looking, it will generally be found that the water is polluted in other respects, and an order should be given that the well should be opened, examined, and cleaned out, and any ascertained source of pollution removed. In towns or villages where there is a public water supply, and the premises are within easy reach of a water-main, there should be no hesitation in requiring the well to be closed; or if the ground is so saturated with filth that it is hopeless to expect that any alterations can ensure subsequent safety, an order to close the well should still be insisted on. But supposing the water is tolerably clear, or quite clear, what are the inferences to be drawn from the qualitative examination? If there is distinct coloration on the addition of the Nessler re-agent, but very little precipitate, and with no distinct indications of either nitrites, nitrates, or chlorides, it shows that the water is a soft water and fit for use, and that the ammonia is either derived from rain water or is probably of vegetable origin. If ammonia, nitrites, and chlorides in excess are all present, the water is polluted and unfit for use. A water with an excess of chlorides, and which yields a large flocculent precipitate on the addition of the Nessler re-agent, but does not become tinted, and gives no indication of the presence of nitrites, nitrates, or organic matter, is a hard water, but otherwise fit for use. Should a water contain nitrates and traces of nitrites, but give no distinct indication of ammonia or chlorides, it may be considered fit for use. If nitrates and chlorides are

both present in any excess, the water should be regarded as a very suspicious water, and be submitted to a more careful examination, even though the Nessler re-agent should produce no distinct coloration.

In giving instructions as to what action should be taken when a sample of well-water is found to be polluted, it is always advisable when there is no public supply within reach to recommend that the well should be opened and examined. The pollution may arise from want of cleansing, or from leakage from a drain, cesspool, or farm-yard, and it will depend upon the special circumstances of the case as to whether cleansing and removal of the source of pollution will suffice, or whether the well should be closed altogether, and a new one sunk in some other suitable place where there is no risk of pollution. It is evident therefore that detailed information with regard to the situation and surroundings of a polluted well is of very material service in advising as to what particular steps should be taken; but so far as the water itself is concerned the medical officer of health need only report that it is contaminated and unfit for use. Should his recommendations, when notified in the regular way by the sanitary inspector, not be complied with, it may become necessary to submit the water in question to a quantitative analysis, in order to obtain a magistrate's order to cleanse, repair, or close the well, as the case may be.

2. *Quantitative Analysis.*

With the exception of proposed new public supplies, which should in all cases be submitted to a very minute analysis, the only points which require determination in an ordinary quantitative analysis are

the total solids, the hardness, the chlorides, and the organic matter as represented by the free and albuminoid ammonia.

(1.) *Total Solids.*—The amount of total solids is ascertained by evaporating a known portion of the water to be examined to dryness. Into a platinum dish which has been carefully cleaned, dried, and weighed, pour 70 cubic centimetres of the sample of water; place the dish in the water or steam-bath, and evaporate to dryness, then wipe the dish externally, and weigh. The difference between the two weighings gives the weight of the residue yielded by 70 cubic centimetres of water. Seventy c. c. are taken because each milligramme of residue counts for one grain of total residue in a gallon of water, inasmuch as a gallon of water weighs 70,000 grains, and 70 c. c. weigh 70,000 milligrammes.

If the operator has a very delicate balance, and has had some experience in chemical manipulation, 25 c. c. of the water to be examined will usually be found sufficient, but in that case the result in milligrammes must be multiplied by 2·8 (4 × ·7) in order to obtain the total amount of residue in grains per gallon. Thus, to take the following example:—

Weight of dish . . .	24·286	grammes.
,, dish and residue .	24·295	,,
Therefore weight of residue =	·009	,,

But ·009 grammes are 9 milligrammes, and multiplying this number by 2·8 gives 25·2 grains as the amount of solid residue in a gallon of the water examined. If 100 c. c. are taken, the multiple will of course be ·7. The times occupied in the evapora-

tion average about two hours for the 100 c. c., an hour and a quarter for the 70 c. c., and about half an hour when only 25 c. c. are evaporated. In drying the residue, the dish should be put into a hot-air bath, then allowed to cool, and weighed promptly afterwards to avoid deliquescence of the salts.

A very cheap and efficient steam-bath can be made from a pint oil-can by fitting it with a cork which is perforated to admit the stem of an ordinary glass funnel. The can is partly filled with water, and fixed on a retort stand, and the platinum dish is placed in the mouth of the funnel with a piece of folded paper between to permit the escape of the steam.

The total solid residue consists for the most part of mineral matter, and in many waters this is composed chiefly of carbonate of lime. It is difficult to fix the maximum amount of permissible solid residue in drinking water. In public supplies it certainly ought not if possible to exceed 30 grains per gallon, but many usable well waters are found to contain double this amount.

The following are examples of the amount of solids in different waters :—

	Grains per gallon.
Loch Katrine	2·30
Bala Lake	3·18
London Thames Companies	21·66
Rochdale Spring	25·93
Norwich Artesian well	26·70

If a complete quantitative analysis of the saline constituents is required, a much larger quantity of water must be evaporated, but the presence and amount of the more important constituents may be approximately determined as follows :—

a. (*Lime.*)—Pour a little of the water into a test-glass, and add a solution of ammonium oxalate. Six grains of lime per gallon will yield a slight turbidity; 16 grains a distinct precipitate; and 30 grains a large precipitate soluble in nitric acid.

b. (*Magnesia.*)—In a good water there should only be a slight haziness, or none at all, on the addition of ammonia.

c. (*Sulphates.*)—Acidulate with a few drops of hydrochloric acid and a solution of barium nitrate. A good water should not give more than a slight haziness.

It is seldom, however, that these subsidiary tests are required. A more important indication is obtained by incinerating the residue over a flame, when, if blackening occurs, the presence of organic impurities may be inferred, and should a bad smell be given off at the same time, it is almost certain to be derived from impurities of animal origin.

(2.) *Hardness.*—It has already been pointed out that a water is hard or soft according to the amount of solid residue which it contains. Thus a water which contains only three to four grains of residue, such as the Loch Katrine water, is an exceedingly soft water; a water containing eight to ten grains is a moderately soft water; while those which contain twenty grains and upwards are hard waters. For purely sanitary purposes, therefore, the determination of the hardness is seldom required if the total solid residue has been ascertained. The hardness of a water is due to the presence of earthy salts, generally carbonate of lime and sulphate of lime and magnesia. The former is deposited on boiling, and is represented by what is called the removable hardness, while the latter, inasmuch as it is not

affected by boiling, is called the permanent hardness. The *rationale* of the process, as first explained by the late Professor Clark, will be understood when it is remembered that if an alkaline oleate, such as soap, is mixed with pure water, a lather is formed almost immediately; but if salts of lime, magnesia, baryta, iron, or alumina are present, oleates of these bases are formed, and no lather is given until the earthy bases are thrown down. As the soap will combine in equivalent proportions with these bases, it is only necessary to make the solution of soap of known strength by standardising it with a known quantity, say of chloride of calcium, to be able to determine the amount of lime or its equivalent of other salts in the water—so much soap required before a lather is produced represents so many degrees of hardness. The standard solutions are prepared and determined according to the following method, proposed by Messrs. Wanklyn and Chapman:—Make a solution of pure calcium chloride of 1·110 grammes to the litre of distilled water. Each cubic centimetre of this solution contains an amount of calcium chloride equal to one milligramme of carbonate of lime. The standard soap test is made by pounding together two parts of lead plaister with one of carbonate of potash, exhausting repeatedly with alcohol at 90 per cent, and using about thirty times as much alcohol as lead plaister. This solution is allowed to stand for some time, and is then filtered, and afterwards diluted with its own volume of water. In order to standardise it, 10 c. c. are taken and put into a bottle with 70 c. c. of pure water; the chloride of calcium solution is now added until frothing stops, care being taken to shake properly; and from this trial experiment it is easy to calculate how much dilu-

tion of the soap solution is requisite in order to make 17 c. c. of the soap-test use up 16 c. c. of the chloride of calcium solution. The dilution should be made with alcohol of 50 per cent, and the soap-test carefully verified after it has been made up. This is done by adding 16 c. c. of the standard solution of calcium chloride to 54 c. c. of distilled water, thus making a solution of 70 c. c. which should exactly be neutralised by 17 c. c. of the standard soap-test.

A much easier method of making the soap-test, and one which gives fairly accurate results, is to dissolve ten grammes of green Castile soap in a litre of weak alcohol of about 35 per cent. One cubic centimetre of this solution also precipitates one milligramme of carbonate of lime. Either solution, therefore, may be used, and the mode of employing the test is as follows:—

Into a clear glass-stoppered bottle, capable of holding about 250 c. c., put 70 c. c. of the water. Add slowly from a burette the standard soap solution, and shake well until a persistent lather is formed, noting accurately the amount of solution used. Each c. c. of the solution consumed indicates one grain of carbonate of lime or its equivalent in a gallon of water. If, after adding 17 c. c. of the solution, no lather is formed, add 70 c. c. of distilled water and mix, and continue the addition of the soap solution. Should no lather be formed until other 17 c. c. are consumed, other 70 c. c. of distilled water must be added, but in making the calculation for hardness, 1 must be deducted from the number of c. c. of soap solution used for each 70 c. c. of water which have been added, and this deduction is necessary because 70 c. c. of distilled water would

themselves neutralise about 1 c. c. of soap-test. Suppose, for example, that 18 c. c. of soap-solution have been required, then 1 must be deducted for the 70 c. c. of distilled water which were added, and the hardness of the sample in question is put down as 17 degrees. In other words, the total soap-destroying power of the water is equivalent to 17 grains of carbonate of lime per gallon. The permanent hardness is obtained by boiling 70 c. c. of the water for about an hour, and making up the loss by evaporation with distilled water. During boiling, the bi-carbonate of lime is decomposed and the carbonate deposited, and thus the water becomes softer. After allowing to cool and filtering, the permanent hardness is determined in the same way as the total hardness, and the difference between these two, as already stated, is the removable hardness.

According to Wanklyn's method, the degrees of hardness represent "the potential carbonate of lime," and in translating them into Clark's degrees, it is necessary to deduct 1. Thus, in the above example, the degrees of hardness, according to Clark's standard, would be 16°.

Altogether the importance of this test has been greatly over-estimated, and it is seldom that the medical officer of health will deem it necessary to employ it.

(3.) *Chlorides.*—The estimation of chlorine as chlorides in water can be readily determined volumetrically by means of chromate of potash, and a standard solution of nitrate of silver. This solution is prepared by dissolving 4·79 grammes of dry nitrate of silver in a litre of distilled water. As chromate of silver is soluble in acids, it is necessary that the nitrate of silver used should be neutral. Each c. c. of this

solution precipitates 1 milligramme of chlorine. 70 c. c. of the water to be examined are put into a beaker or evaporating dish, and a small crystal of pure chromate of potash, or a few drops of a strong solution of this salt added, sufficient in either case to produce a distinct yellow tint. The standard solution is then dropped carefully in from a graduated pipette or burette, and directly the first faint tinge of red is discernible and remains permanent on stirring, the whole of the chlorine is precipitated, and chromate of silver, which is a dark red, is formed. The number of c. c. of the solution used before this red tinge is obtained represents the number of grains of chlorine per gallon of water. If, for example, 3·5 c. c. of the solution have been required, the water contains 3·5 grains of chlorine per gallon.

The following are examples of the amount of chlorine in different waters:—

	Grs. per Gallon.
Thames at Kew	·847
Thames at London Bridge	4·452
Bala Lake	·706
Polluted well at Rugby	7·5

The indications afforded by the chlorine test have previously been dwelt upon in the remarks on the qualitative examination of water, and they need not therefore be further referred to here.

(4.) *Ammonia and Organic matter.*—Of the two rival methods of estimating the organic matter in water—namely, that of Frankland and Armstrong, and that devised by Wanklyn, Chapman, and Smith—there is a general concurrence of opinion that the latter is especially suited for the medical officer of health, because it is easy of application, and yields sufficiently accurate

results for ordinary hygienic purposes. Frankland's process of estimating the organic carbon and nitrogen is a method of no small difficulty, and in the hands of any but an experienced chemist the risk of experimental error is very considerable. What is known as the *Ammonia process*, therefore, will be the process described here. For a full description of this process the reader is referred to Mr. Wanklyn's excellent text-book on water analysis, from which the following remarks are for the most part collated. The *rationale* of the process depends upon the fact that vague and indefinite nitrogenous bodies can be converted into a definite compound, namely ammonia, and that in this way they can be estimated and expressed as ammonia. Owing to the excessive minuteness of the quantities of nitrogenous compounds which distinguish between a good and a bad water, it is convenient to adopt a much finer scale of measurement than is requisite for the saline constituents; and the amount of ammonia is accordingly expressed by milligrammes per litre, or so many parts in a million. Indeed the delicacy of the process is such that there is no difficulty in being able to discover one part of recent sewage in 2000 parts of drinking water. The re-agents which are employed are the Nessler test, a standard solution of ammonia, a saturated solution of carbonate of soda, and a solution of potassium permanganate and caustic potash.

a. Nessler Test.—Dissolve, by heating, 35 grammes of iodide of potassium, and 13 grammes of corrosive sublimate in about half a litre of distilled water, and afterwards add gradually a cold saturated solution of corrosive sublimate, and keep stirring until the red colour produced begins to be permanent. Then add

160 grammes of caustic potash dissolved in about 200 c. c. of distilled water, and dilute with sufficient water to bring the whole up to a litre. To render the test sensitive, add about 20 more c. c. of the saturated solution of corrosive sublimate, and allow it to stand in a stoppered bottle until the precipitate has subsided. The clear liquid may now be decanted and kept in a tightly stoppered stock bottle ready for use.

b. Standard Solution of Ammonia. Dissolve 3·15 grammes of crystallised sal ammoniac or ammonium chloride in one litre of distilled water. Every cubic centimetre of this solution contains one milligramme of ammonia. This is termed the strong solution, and is the most convenient to keep. To prepare the dilute solution, put 5 c. c. of the strong solution into a half-litre flask, and fill up with distilled water. This is the standard solution of ammonia, and contains 0·01 milligramme of ammonia in one cubic centimetre of water.

c. The Saturated Solution of Carbonate of Soda may be prepared by boiling an excess of the common carbonate in distilled water. About 10 c. c. of this solution is the proper quantity to use, or instead of the solution, about one gramme of the dry carbonate of soda, which has just been ignited, may be employed. The carbonate of soda is used in order that the free ammonia may be more easily dispelled on distillation.

d. The Permanganate of Potash and Caustic Potash Solution is prepared as follows:—Dissolve 8 grammes of crystallised permanganate of potash, and 200 grammes of solid caustic potash in one litre of distilled water. Boil the solution for some time to free it from all traces of ammonia, and afterwards replace the water

lost by evaporation by adding sufficient distilled water to make up the litre.

The distilled water which is used to make up the various solutions may be obtained of sufficient purity from any common drinking water, if care is taken to reject the first portions of distillate, and the distillation is not pushed too far. It should always be carefully tested before being used, and so chemically pure that in 100 c. c. there ought not to be 0·005 milligramme of ammonia.

The following is a list of the apparatus required for the process (see also Appendix) :—A stoppered retort capable of holding at least one litre; a Liebig's condenser; a good sized Bunsen's lamp or burner; a retort-holder; about half a dozen Nessler glasses made of white glass, and with a mark at 50 c. c.; a half litre flask; a graduated burette marked into c. c. to measure off the standard solution of ammonia; and a pipette marked to hold 2 c. c. It need hardly be said that the greatest care must be taken to have the whole of the apparatus thoroughly clean before it is used. Glass vessels should first be washed out with a little strong hydrochloric or sulphuric acid, and afterwards with pure water.

The analysis itself is thus performed: After mounting the retort on the holder, and properly connecting it with the Liebig's condenser, half a litre of the water to be examined is poured into it, and 10 c. c. of the solution of carbonate of soda added. The Bunsen lamp is now lighted, the retort thrust well down into the flame, and 50 c. c. are distilled over into a Nessler glass and *Nesslerised*. Then distil over 150 c. c. and throw this distillate away. This amount is thrown away because it has been found that the first distillate contains exactly three-fourths of the free ammonia

present in the water, and it is therefore a waste of labour to Nesslerise the whole of the four 50 c. c. distilled over. There are now 300 c. c. left in the retort, and in order to liberate the "albuminoid ammonia," 50 c. c. of the permanganate of potash and caustic potash solution, are poured into the retort by means of a wide funnel. To prevent bumping, which is very liable to occur with a bad water, the retort should be gently shaken, so as to give the mixture a wavy motion. The distillation is then continued, and three separate distillates, each of 50 c. c., taken and Nesslerised.

What is called Nesslerising is the process of ascertaining the strength of a dilute solution of ammonia by means of the Nessler re-agent, and is indeed one of the most beautiful examples of colorimetric analysis. Let the first distillate of 50 c. c. be taken as an illustration. To this distillate, which is contained in one of the Nessler glasses, 2 c. c. of the Nessler re-agent are added by means of the 2 c. c. pipette, which also serves as a convenient stirrer. If, after stirring and waiting about a couple of minutes, the liquid assumes a rich deep brown, it contains much ammonia; if even a distinct brown tint is developed, it contains a considerable quantity of ammonia; but if it remain colourless it does not contain so much as ·005 milligramme. When only a light-yellowish tint is produced, the amount of ammonia present is comparatively small. In any case, however, the exact amount is determined by comparing with a known solution of ammonia. The depth of tint in the distillate is imitated by mixing in a Nessler glass more or less of the dilute standard of ammonia contained in the burette with distilled water, and filling

up to 50 c. c., and then adding 2 c. c. of the Nessler re-agent. If, after stirring and waiting two or three minutes, the tint developed in the artificially prepared solution is too dark or too light, it is necessary to make another artificial solution of less or greater strength, as the case may be. With a little practice it is easy to approximate very closely to the exact amount of the standard solution of ammonia which will be required to produce a tint on the addition of 2 c. c. of the Nessler re-agent, which will harmonise completely with the tint of the distillate. In order to be able to compare the tints accurately, the Nessler glasses should be placed on a white porcelain slab or sheet of white paper. The number of cubic centimetres of the standard solution of ammonia, which on the addition of the Nessler re-agent were required to reproduce the exact tint given by the distillate, are noted, and the amount of "free ammonia" contained in the sample of water can then be readily calculated.

The other three distillates which contain the albuminoid ammonia are Nesslerised in the same way, and the amount of the standard solution of ammonia, which was required to imitate the tint in each case, is also noted. These several amounts added together represent the total "albuminoid ammonia" contained in half a litre of the water. It has already been pointed out that the first 50 c. c. which were distilled over contain three-fourths of the whole of the "free ammonia," and that therefore the next 150 c. c. distilled over may be thrown away. It was formerly the practice of Mr. Wanklyn to Nesslerise the whole four 50 c. c. to obtain the total of the free ammonia, but the amount contained in the first distillate was

found to bear such a constant ratio to the amount contained in the other three distillates, namely, as 3 to 1, that it becomes a needless expenditure of labour to Nesslerise them. The rule, therefore, is to add one-third to the amount of ammonia found in the first distillate, in order to obtain the whole of the free ammonia.

Remembering now that each cubic centimetre of the standard solution contains ·01 milligramme of ammonia, the calculation in any given case becomes very simple. For example, suppose the amount of dilute standard solution of ammonia required to match the tint in each case to be as follows:—

Free ammonia distillate	. . . .	2 c. c.
Albuminoid ammonia	1st distillate . .	5 „
	2d „ . .	2·5 „
	3d „ . .	·5 „

then we arrive at the following amounts:—

			Milligrammes.
Free ammonia	$= \cdot 02 + \frac{\cdot 02}{3}$	=	·027
Albuminoid ammonia	1st distillate	. .	·05
	2d „	. . . .	·025
	3d „	. . . .	·005
	Total albuminoid ammonia	. .	·08

But inasmuch as half a litre of water was taken for analysis, these results must be multiplied by 2 in order to arrive at the amounts per litre, or per million parts. In the above example, therefore, the results would be stated as follows:—

		Parts in a million, or milligrammes per litre.
Free ammonia	=	·054
Albuminoid ammonia	=	·16

In this process of water analysis it will be observed from the above description that ammonia is to be

looked for at two stages; firstly, in distilling off with the carbonate of soda solution; and secondly, on distilling off with the alkaline permanganate solution. The first portion of the ammonia is called the "free ammonia," because it is obtained from the decomposition of those organic impurities in water which are of simple constitution, such as the ureal class, as well as the ammonia which may be present as ammonia. The second portions of ammonia are named "albuminoid ammonia," because the ammonia which is given off is derived from the oxidation of those more complex nitrogenous impurities which are closely allied to albumen.

The following are examples of pure, indifferent, and bad samples of water as determined by the ammonia process:—

	Free Ammonia, parts per 1,000,000.	Albuminoid Ammonia, parts per 1,000,000.	Quality	Name of Authority
Loch Katrine . .	·004	·08	Good	Wanklyn
Water from Kent Company's mains . .	·01	·02	,,	,,
Edinburgh Water Supply, Colinton, 1867 .	·14	·08	Indifferent	,,
Great St. Helen's pump, London .	3·75	·18	Bad	,,

With regard to the inferences which may be deduced concerning the quality of a water as indicated by this method of examination, Mr. Wanklyn has laid down the following rules in the third edition of his work on water analysis:—"If a water yield ·00 parts of albuminoid ammonia per million, it may be passed as organically pure, despite of much free ammonia and chlorides; and if, indeed, the albuminoid ammonia

amount to ·02, or to less than ·05 parts per million, the water belongs to the class of very pure water. When the albuminoid ammonia amounts to ·05, then the proportion of free ammonia becomes an element in the calculation; and I should be inclined to regard with some suspicion a water yielding a considerable quantity of free ammonia, along with ·05 parts of albuminoid ammonia per million. Free ammonia, however, being absent or very small, a water should not be condemned unless the albuminoid ammonia reaches something like ·10 per million. Albuminoid ammonia above ·10 per million begins to be a very suspicious sign; and over ·15 ought to condemn a water absolutely." There is no doubt, however, that there are many surface well-waters in country districts containing even more than ·15 parts per million of albuminoid ammonia, and to which no bad effects can be traced, but in these cases it is probable that the ammonia is chiefly derived from vegetable matter. If the quantity of chlorine found in a water is exceedingly small, any excess of albuminoid ammonia would indicate that the nitrogenous matter present is of vegetable and not of animal origin, and therefore comparatively innocuous. At the same time it should be remembered that there might be the same absence of chlorine if the water becomes polluted from the presence of the body of a dead animal in a well or cistern.

In conducting a water analysis it is expedient, if the amount of solids is to be taken, to commence the evaporation for the solids first, then to commence distilling for the ammonia, and while the evaporation and distillation are going on, to determine the amount of chlorides, and the degree of hardness if that be con-

sidered necessary. It is always advisable to keep a detailed record of the results of every analysis, in a book set apart for that purpose. The form of report or certificate will of course vary according to the number of data, and the mode of analysis, but the following hints will indicate generally how it should be drawn up:—

Date of reception of sample, size and description of bottle or bottles, how stoppered or sealed, and how labelled.

Physical Examination.

Appearance .	(Clear, or slightly turbid, etc.)
Taste . .	(Tasteless, or unpleasant, etc.)
Odour . .	(Odourless, fœtid, etc.)
Deposit . .	(Slight or large, dirty-looking, flocculent, etc.)

Microscopic Examination.

(Sandy particles, vegetable matters, animal matters, vibriones, etc.)

Chemical Examination.

Qualitative results:—

Nitrites . .	(None—traces—large amount.)
Nitrates . .	(None—slight traces, etc.)
Sulphates . .	(None—slight traces, etc.)
Metals . .	(None—traces of lead, etc.)

Quantitative results:—

Total solids .	(In grs. per gallon.)
Chlorides . .	(In grs. per gallon.)
Hardness, total .	(In degrees.)
„ permanent	(In degrees.)
Free ammonia .	(Parts per million.)
Albuminoid ammonia	(Parts per million.)

Remarks as to whether the water is soft or hard, of good quality and fit for use, or whether it is polluted and unfit for use.

Date of analysis,—signature, etc.

Exclusive of the microscopic examination, which is seldom undertaken or required, a water analysis giving

the above data may be completed in about an hour, provided of course that the operator is fairly expert at his work and has all his test and standard solutions prepared beforehand. The busy medical officer of health may obtain most of these solutions, as well as distilled water, from chemists, but he should always make blank experiments to test their purity and quality.

Although I have thus far endeavoured to describe clearly and concisely the various steps of an ordinary water analysis, I nevertheless consider it very essential that every one who has to undertake this kind of work should receive some lessons in the laboratory of a competent analyst. If he is precluded from doing this, he may teach himself, provided that he has a fair knowledge of elementary and practical chemistry, but in this case he ought to experiment with samples obtained from a public supply, and compare his results with those of recorded analyses of that supply.

As already stated, any proposed new public supply should be submitted to a full quantitative analysis of its saline and other constituents, and for this purpose samples should be sent to a professed analyst. It should not only be usable, but the best which can be procured within the limits of reasonable expenditure. All waters subjected to filtration should be examined from time to time, to ascertain that the filtering process is carried on efficiently. Any water which gives indications of having become contaminated with animal or other impurities, and which has hitherto been good and wholesome, should be entirely disused until the source of contamination has been discovered and removed.

A list of tests, etc., is given in the Appendix.

CHAPTER VIII.

IMPURE WATER, AND ITS EFFECTS ON PUBLIC HEALTH.

Although impure water has long been recognised as one of the most potent causes of disease, it is only of recent years that minute investigation has succeeded in demonstrating the terrible mortality which it inflicts on all classes of the community. It is true that chemical analysis often fails in detecting the special impurities on which the development of certain diseases depends; it is also true that, even when impurities are detected, it is extremely difficult to estimate their exact etiological value; nevertheless, the broad fact remains, and it is founded on evidence of the most conclusive kind, that a vast number of cases of disease are attributable to the use of impure water, and there are good grounds for believing that, as investigations become more frequent and precise, a continually increasing class of such cases will be discovered. It must also be remembered that the effects of impure water, like the effects of impure air, may engender a general impairment of the health, without giving rise to well-pronounced disease.

Water impurities and their effects may be conveniently considered as follows:—Firstly, water rendered impure by an excess of mineral substances; secondly, water rendered impure by the presence of vegetable matter; thirdly, water rendered impure by animal organic matter.

SECTION I.—WATER RENDERED IMPURE BY AN EXCESS OF MINERAL SUBSTANCES.

As all potable waters contain a certain amount of mineral matters, it is extremely difficult to decide the quantities of these ingredients which may be present, either singly or collectively, without producing bad effects. This much, however, may be said, that waters of a moderate amount of hardness, provided that the hardness depends chiefly on the presence of calcium carbonate, are not found to be detrimental to health. A water of 8 or 10 degrees of temporary hardness, equivalent to about as many grains per gallon of total mineral solids, may be pronounced good and wholesome, while one of as many degrees of permanent hardness would prove injurious to many persons. With regard to the wholesomeness of Thames water, with a hardness averaging 15 degrees before boiling and 5 degrees after, the evidence given before the Royal Commission on Water Supply, 1869, is somewhat conflicting; for while Dr. Letheby considered a moderately hard water, such as the Thames water, best suited for drinking purposes and the supply of cities, Dr. Parkes maintained that the amount of hardness should not exceed 10 or 12 degrees if possible. Mr. Simon and Dr. Lyon Playfair, on the other hand, although they did not condemn the London water on account of its hardness, both expressed themselves in favour of a softer water for purposes of health. The inference that may be drawn from this and other evidence would therefore appear to be this, that the total hardness of a good water ought not to exceed 15 degrees, nor the permanent hardness 5; or, in other words, that even in a moderately hard water,

calcium carbonate must always greatly exceed the magnesium and calcium sulphates and sodium chloride.

The symptoms referable to an excess of hardness, arising from the presence of earthy salts, are mainly of a dyspeptic nature. According to Dr. Sutherland, the use of the hard waters derived from the red sandstone rocks underlying Liverpool, produced, in many cases, constipation and visceral obstruction, and, an excess of calcium and magnesium sulphates (7 to 10 grains per gallon) has been known to produce diarrhœa.

The special disease, however, which, more than any other, seems intimately connected with the mineral ingredients of water, is goïtre. In Nottingham, where the disease prevails to a certain extent, the common people attribute it to the hardness of the water; and in other parts of England, such as Yorkshire, Derbyshire, Hampshire, and Sussex, it is found to prevail only in those districts where the magnesian limestone formation abounds. According to Dr. Coindet of Geneva, the disease is speedily produced in persons drinking the hard pump water in the lower streets of that town, while in other parts of Switzerland the use of spring water has been followed by the production or augmentation of the disease in a few days. In India, again, the researches, more especially of Dr. M'Clellan, show very conclusively that it is found to prevail only where the magnesian limestone formation prevails. Whether lime and magnesian salts, or ferrum sulphide, as has been suggested by M. Saint-Lager, be the active agents in producing the disease, has not yet been rendered quite clear; but it appears certain that goïtre is originated by water-impurities, and that these are of an inorganic and not organic nature. According to Johnston,

the prisoners in Durham jail were at one time affected with swellings of the neck, and on analysis the water-supply was found to contain 77 grains of lime and magnesian salts per gallon. The swellings disappeared when a purer water was obtained. (*Parkes.*)

With regard to this subject, Dr. Brushfield of Brookwood, Woking, has directed my attention to the prevalence of goïtre at Pirbright, a village near Brookwood, especially amongst the inhabitants who live along the course of a certain brook. Even the clergyman's wife contracted the disease after she had been resident there for a short period. But instead of magnesian limestone, the geological formation throughout the district consists of Bagshot sands overlying the London clay. Goïtre has become much less common since sanitary matters have been better attended to.

The effects of minute traces of metallic compounds in drinking water are as yet comparatively unknown. It is quite possible that the sanitary condition of a district may in some measure depend on impurities of this description, and, as Mr. Wanklyn suggests, that the salutary effect of "change of air" may be partly due to change in the minute metallic impurity in the water of the parts of the country which are visited.

Of the metallic ingredients, the effects of iron and lead have been the most fully ascertained. It would appear that iron, if present in quantities large enough to impart a chalybeate taste to the water, often produces headache, slight dyspepsia, and general *mal-aise,* while impregnation with lead from leaden cisterns or pipes has frequently been followed by symptoms of lead-poisoning. In the case of the ex-royal family of France, many of whom suffered when at Claremont from this species of

water contamination, the amount did not exceed one grain per gallon; indeed, from cases which have since occurred, it seems probable that the habitual use of water containing from one-tenth to one-twentieth of a grain per gallon may be attended with danger. In his investigations with regard to the Devonshire colic, which formerly prevailed to a great extent, Sir George Baker found that eighteen bottles of cider which he examined contained $4\frac{1}{2}$ grains of lead, or a quarter of a grain to each bottle. The impregnation arose from lead being employed in the construction of the cider troughs. With regard to the minor effects of lead-poisoning, there are good grounds for believing that many obscure forms of disease, partaking more particularly of the nature of dyspepsia and colic, are due to this cause.

Arsenic, copper, or mercury, are only found in the drinking waters of this country in injurious quantities when streams are polluted by the washings from mines or chemical works.

Section II.—Water rendered impure by Vegetable Matter.

Vegetable matter may be present in water either in suspension or in solution. In peaty water, which is characterised by its brownish tint, the dissolved impurities sometimes do not exceed two grains per gallon. In the absence of a purer supply, a water of this description cannot be pronounced objectionable, provided that it is not stored in leaden cisterns, and that the supply is constant. If stored in open air ponds or reservoirs, it is improved by oxidation and light; and it is further improved by filtration through gravel and sand.

Water containing a considerable amount of vegetable matter, partly in suspension and partly in solution, is decidedly unwholesome. It has been known to produce violent outbreaks of diarrhœa, and, since the days of Hippocrates downwards, it has been popularly acknowledged to be productive of ague and other malarious ailments. In this country there are several instances on record, that ague has been much lessened in small communities by using well instead of surface water; and there is strong presumptive evidence that, apart from the influences attaching to improved drainage, the great decline of this disease throughout many parts of England where it formerly prevailed, is in some measure due to the use of purer water. (*Parkes.*)

Section III.—Water rendered impure by Animal Organic Matter.

From a sanitary point of view, this is by far the most important class of water impurities. The presence of putrescent animal matter, whether it has percolated through the soil from cesspools or other filth-accumulations into wells, or whether it has been discharged from open sewers into streams and rivers, converts drinking water into a dangerous poison, fraught with disease and death. It is true that to a certain extent the process of filtration through a porous soil tends to render less hurtful the sewage which dribbles into a well, but after a time this purifying power is lost, the soil becomes sodden, and the sewage enters unchanged. It is also true that, given a sufficiently large stream, a sufficient length of course, and a sufficient length of time, the greater portion of the sewage discharged into a river

will become converted into harmless products by oxidation. Yet neither process can be trusted, however complete it may appear to be. There is always danger lurking in a water which is known to be contaminated with animal matter, and more especially when such matter is partly composed of the evacuations of patients suffering from certain specific diseases, such as cholera or enteric fever. The germs of disease, which may be communicated in this way, have a tenacity of life or chemico-physical power altogether beyond our knowledge.

Leaving out of consideration the question whether animal organic matter in suspension or in solution is the more injurious to health, it would appear that it is the quality rather than the quantity which determines the danger. As already stated, a trace of fæcal matter, especially when undergoing active chemical change, may render a public well poisonous, while a stream of sewer-gas may contaminate the contents of a cistern, and be the means of prostrating a whole household.

The principal diseases which have been proved to be produced by this class of water impurities are, cholera, enteric fever, dysentery, and diarrhœa.

1. *Cholera.*—Although much had been previously written with regard to the etiology and spread of cholera, it was not generally surmised that the disease could be propagated by a polluted water-supply until the late Dr. Snow published the results of his researches in 1849. At first Dr. Snow's views were rejected by some, or questioned by others, but in 1854 there occurred a violent outbreak of cholera in the parish of St. James, Westminster, the causes of which were inquired into by a committee of medical men, whose

report fully substantiated Dr. Snow's conclusions. Between the 31st August and the 8th September of that year, as many as 486 fatal cases occurred within an area bounded by a circle whose radius scarcely exceeded 200 yards. On inquiring into the local peculiarities of the epidemic, Dr. Snow found that the sufferers had been in the habit of drinking the water supplied by a pump-well in Broad Street, which had a great reputation for freshness and sweetness. An analysis of the water proved that it was highly charged with animal impurities, and, at Dr. Snow's earnest solicitation, the handle of the pump was removed by order of the vestry on September 8th, to prevent further use of the water. After this the disease gradually subsided, and ultimately disappeared. It was made manifest, by a subsequent examination, that the sewage of a neighbouring house had leaked into the well, and it was further ascertained that the evacuations of a patient residing in the house, and who was suffering from diarrhœa, or actual cholera, must have mingled with the sewage immediately before the occurrence of the general outbreak. No evidence could well be more convincing that, in this instance at least, the choleraic poison had been conveyed by the drinking water.

Amongst other remarkable outbreaks which go to prove that this mode of cholera propagation is not at all uncommon, may be mentioned the following:—In the autumn of 1865, a gentleman and his wife, from the village of Theydon-Bois in Essex, had been lodging at Weymouth for two or three weeks, and returned home towards the end of September. On their way home they passed through Dorchester, where the gentleman was seized with diarrhœa, vomiting, and cramps,

which continued more or less during the next day, and the day following, when they reached Theydon-Bois. During the journey the wife also began to complain of abdominal pain, which was followed by diarrhœa and eventually by cholera, from which she died. A few days after their return, the disease rapidly attacked other members of the household, so that, "within a fortnight, in that one little circle, eleven persons had been seized with cholera—mother, father, grandmother, two daughters, son, doctor, serving-lad, servant-maid, labourer, and country-woman; and of these eleven only three survived—the son, a daughter, and the serving-lad. Later, in the country-woman's family, there was another fatal case. It cannot well be doubted," continues Mr. Simon, "but that the exciting cause of this succession of events was, in some way or other, the return of the parents from Weymouth, of the father with the remains of choleraic diarrhœa still on him, of the mother with apparently the beginnings of the same complaint. But this is only part of the case, and the remainder teaches an impressive lesson. All drinking water of the house came from a well beneath the floor of the scullery, and into that well there was habitual soakage from the water-closet." (*Eighth Report of the Medical Officer of the Privy Council.*)

In addition to Mr. Simon's report on the cholera epidemics of London in 1848-49 and 1853-54, in which there is sufficient evidence to show that the prevalency of the disease in certain districts was almost entirely determined by the degree of impurity of the water-supply, the conclusions, more especially of Dr. Farr and Mr. Radcliffe, with regard to the localisation and distribution of the epidemic of 1866, are, if pos-

sible, more confirmatory still. Thus, Dr. Farr, in his evidence before the Royal Commission on Water Supply in 1869, states that "in all the districts supplied by the Grand Junction, the West Middlesex, and the Chelsea Water-works Companies, the mortality was about 3 in 10,000; in those supplied by the Southwark and Lambeth Companies, which were formerly so heavily visited, it was about 6 in 10,000; and in those supplied by the New River Company, about 8 in 10,000; while in those supplied by the East London Company, from the Old Ford Reservoirs, it was 79 in 10,000." In effect, the area of explosion was found to be limited to the district supplied by the East London Water Company, and not only so, but Mr. Radcliffe's investigations proved that the water delivered from the Old Ford covered reservoirs had been polluted with water from the filthy uncovered reservoirs, and that these latter had, in all probability, been contaminated with soakage from the River Lea, which received the evacuations of the first two patients who died of epidemic cholera in the eastern districts.

With regard to Scotland, the evidence of Dr. Stevenson Macadam, as to the influence of impure water on the spread of cholera, is also very conclusive. In a report read before the members of the British Association in 1867, he showed very clearly that the ravages of the disease were coincident in time and place with the use of water from impure wells, and that in all cases the abatement of the outbreak followed the introduction of a pure and fresh supply.

Without quoting further evidence, it is sufficient to state that the weighty authority of Dr. Parkes strongly confirms this view of choleraic contagion; and indeed

the opinions of Professor von Pettenkofer, though at first sight they appear to be antagonistic to the theory, do in reality support it. For, while he considers that the propagation of cholera is due to a fermentation of the rice-water stools, he also maintains that this ferment can only act, and the contagion be generated, under certain local conditions—namely, when there is a damp porous subsoil to receive the ejecta. Although Pettenkofer believes that the air is the sole channel by which the cholera miasm, thus generated in the soil, is spread, there is no doubt that the bearing of the geological influence amounts only to this,—that where populations are living on a damp open subsoil, with no artificial water-supply nor any efficient system of drainage, there the drinking water, as well as the local atmosphere, is almost certain to be largely polluted by those fæcal impurities amid which the diarrhœal contagia are peculiarly apt to multiply. (*Simon.*)

Whether cholera can be produced by animal organic matters not of a specific nature, is still an open question. Very probably the effect of constantly drinking a certain amount of these impurities produces a lowered state of the system and a tendency to diarrhœa, so that, when the cholera poison is abroad in the atmosphere, it finds its victims in largest numbers amongst those who partake of an impure water-supply. This much, however, appears certain, that whenever cholera evacuations make their way into the drinking water, we may expect to find the disease burst forth with the greatest virulence and fatality amongst those who use the water, and that indeed the endemic area will approximate with remarkable closeness to the limits of the district which it supplies.

2. *Enteric or Typhoid Fever.*—The remarks which have just been made with regard to the influence which impure water exerts on the spread of cholera, apply with still greater force to the etiology of enteric fever. For, although there are still some who do not believe in the communicability of the disease, there is a constantly accumulating amount of evidence, which goes to prove not only that the poison of the fever may be conveyed through the agency of water from the sick to the healthy, but that this is the most common mode of propagation. Sir W. Jenner, than whom no higher authority could well be quoted, in commenting on this point, says,—"The spread of typhoid fever is, if possible, less disputable than the spread of cholera by the same means. Solitary cases, outbreaks confined to single houses, to small villages, and to parts of large towns—cases isolated, it seems, from all sources of fallacy—and epidemics affecting the inhabitants of large though limited localities, have all united to support by their testimony the truth of the opinion that the admixture of a trace of fæcal matter, but especially the bowel excreta of typhoid fever, with the water supplied for drinking purposes, is the most efficient cause of the spread of the disease, and that the diffusion of the disease, in any given locality, is limited, or otherwise, and just in proportion as the dwellers of that locality derive their supply of drinking water from polluted sources."

According to Dr. William Budd it also appears to be highly probable that when the poison is conveyed by water, infection is much more certain than when it is disseminated by the air; and in support of this statement he instances an outbreak which occurred in Cowbridge

in Wales in 1853, where, out of some 90 or 100 persons who went to a ball, fully one-third were shortly afterwards laid up with fever. Although the water was not examined, there was satisfactory reason to believe that it was polluted.

Since that date numerous other local outbreaks have been carefully investigated, and some with so much precision and completeness of detail that they are noticed here rather as examples of the painstaking and systematic way in which such inquiries should be conducted, than as proving this mode of propagation of enteric fever:—

(1.) In the spring of 1867, Dr. Thorne, one of the Health Inspectors of the Privy Council, was ordered to proceed to Winterton in Lincolnshire, to inquire into the causes of the excessive mortality from enteric fever which had prevailed more or less during the previous two years in different parts of the town, but had latterly assumed alarming proportions. The small town numbered about 1800 inhabitants, of whom about nine-tenths consisted of the labouring classes, living for the most part in well-built cottages and earning good wages. Absolute poverty was little known amongst them, intemperance was rare, and only in two instances was there any overcrowding. Moreover, the situation of the town was healthy, inasmuch as it was built on a gentle slope facilitating drainage, and the subsoil was open and porus, consisting of a stratum of oolitic limestone covered by a light marly soil. Yet, with all these advantages, the number of deaths in 1865 amounted to 51, and in 1866 to 44, and of these more than a third had died of enteric fever. At the date of Dr. Thorne's visit 55 cases were under treatment, and already 6

deaths had occurred since the beginning of the year. The cause of all this sickness and mortality is best given in Dr. Thorne's own words:—

"The epidemic prevalence of fever in Winterton is undoubtedly to be ascribed to the disgraceful state of the privies, cesspools, ashpits, and wells. With the exception of about six houses, where water-closets have been constructed, all the cottages are provided with privies, which are generally built of brick, and have an aperture at the side or back, through which they can be cleaned out. This aperture I found open in almost all instances, and the result of this is that the contents of at least half the privies in the town run out into the gardens, soak into the earth, and penetrate in many instances into the wells, besides producing the most offensive odour. In addition to this many of the tenants either throw their refuse and slops, including urine, into the yards outside their doors, or else they improvise a receptacle by digging in the ground close to the aperture in the privy wall. The fæcal matter pours into it, and they thus add to their previous list of nuisances that of an open cesspool. In some instances ashpits have been built, but these are uncovered, and since urine and the bowel discharges of the typhoid patients are thrown into them, in addition to other refuse, they are but little better than open privies. All these sources of fæcal fermentation are situated, as a rule, close to the houses, and in some instances within a few feet of the back doors, and just under the windows. The wells are also in their immediate neighbourhood, and many of the inhabitants informed me that their water was so bad that they had been compelled to discontinue drinking it. In one instance I found the space between two pig-

styes entirely occupied by a well 3 feet in diameter. Fever is present in the house to which this well is attached, but since the occupants do not use it, the necessarily contaminated condition of the water cannot be considered to bear upon the disease. Given the existence of typhoid fever in a town, it is hardly possible to conceive of conditions more favourable for its spread than those existing in Winterton."

Then follow details, and amongst them these:—

Behind a group of four cottages there was a small open court common to them all, and in this court a well to supply the drinking water. Within a circuit of 14 feet round the well, Dr. Thorne found a choked-up drain; an ashpit, on which the fever evacuations were thrown; two pigstyes; three privies, nearly filled with night-soil; and an open cesspool, into which one of the privies emptied itself. In three of the cottages where the epidemic had been so rife, the inmates used the water from this well; while those living in the fourth, and who drew their water from a neighbour's well, had always enjoyed good health. On examination the water was found to be of a light brown colour and disagreeable taste, and to yield a considerable deposit after standing for some time, which contained a large quantity of organic matter, infusoria, and other animalculæ. (*Tenth Report of the Medical Officer of the Privy Council.*)

(2.) In the autumn of the same year (1867), a severe epidemic of enteric fever broke out in Guildford. Dr. Buchanan, who was the Government Inspector on this occasion, found that during the first twenty-eight days of August, 10 cases of the disease had occurred in different parts of the town; when suddenly, within the

next thirty-three days, the number arose to about 250. As the epidemic was almost exclusively confined to a part of the town which corresponded with a particular section of the public water-supply, suspicions were aroused that this had become polluted; and on further investigation it was ascertained that on a particular day about ten days before the outbreak, the houses in that part of the town had been *exceptionally* supplied with water from a certain high-standing reservoir which had previously been filled from a new well. This well was sunk through a porous stratum of chalk, and in close proximity to it were various sewers, one of which was afterwards found to be leaking in several places. There was no doubt, therefore, that sewage had oozed through the chalk into the well, and had caused the epidemic. An analysis of a sample of the water was subsequently made by the late Professor Miller, the results of which gave unmistakeable evidence of previous sewage contamination. (*Tenth Report of the Medical Officer of the Privy Council.*)

(3.) The account of the epidemic at Terling in Essex by Dr. Thorne is especially valuable as showing the effect of a sudden rise of the ground-water level in a village situated on a porous subsoil, obtaining its water-supply from shallow wells, and allowing its excrementitious filth to accumulate in badly-constructed privies and manure heaps, or to lie indiscriminately in scattered masses on the surface of the ground. Out of a population of 900, about one-third of the number were attacked with enteric fever within a period of two months, and 41 had died. Some ten days before the outbreak, and after a period of prolonged drought, a sudden great rise in the water-level of the wells was

observed to follow a heavy fall of rain and snow; in other words, the shallow unprotected wells sunk in the porous gravel had become converted into so many receptacles for the washings of the filth-sodden soil, and hence the epidemic. (*Tenth Report of the Medical Officer of the Privy Council.*)

(4.) In the beginning of 1873, a severe outbreak of enteric fever occurred in the small town of Sherborne in Dorset, which was investigated by Dr. Blaxall, and which is of extreme interest as having been the first outbreak of the kind, which was clearly traced to the entrance of sewer air into the water mains. Although the water supply was intended to be constant, it was ascertained that in December of 1872, and January 1873, the water was frequently shut off at a point near the reservoir, and that during the month of February it was shut off every night. It was observed that when the water was turned off there were certain water-mains up which there was a sudden rush of air immediately the tap was unscrewed, and as many of the mains communicated directly with closet-pans by means of taps, which were sometimes left open, and which in other instances were broken, there were thus numerous inlets for the entrance of air from the closet-pans into the water-mains. Moreover, if a pan happened to become full of excremental filth, there was the probability of excrement as well as sewer air having been sucked into the mains. In January and February there were about 27 cases of fever in the town, but before the end of April the number altogether had increased to 240, out of a population of 6041. After the first week, during which 73 cases occurred, the water supply was again made constant, and the

epidemic gradually declined. (Mr. Simon's *Reports*, New Series, No. II.)

(5.) Somewhat akin to this outbreak in its mode of causation was the outbreak of enteric fever which occurred at Caius College, Cambridge, towards the close of 1873. Dr. Buchanan's report on this outbreak is such a model of painstaking research and sound reasoning, that, apart altogether from its intrinsic value as a contribution to the etiology of fever, it ought to be read by every medical inquirer as one of the most lucid expositions in the domains of medical logic. Without detailing at any length the various interesting phases of the inquiry, it will be sufficient here to state that the cases of fever numbered 15, that the incidence of these cases was wholly upon the 112 students who were resident in the college, and that 12 out of the 15 cases were confined to 63 students, residing in a particular part of the college, namely Tree Court. The buildings connected with this particular court had been erected only four years previously, and such an amount of care had been expended on the sanitary arrangements that any injury to health arising from drains, sewers, or water-pipes, seemed well-nigh impossible. Nevertheless, the chances as a matter of *a priori* probability, were as 24 to 1 that the cause of fever depended upon some condition peculiar to Tree Court, and not operative, or only operative to a very limited extent, in other parts of the college. After considering all the more usual ways in which enteric fever is known to be spread, and finding that none of them could account for the intensity of the incidence of the outbreak in Tree Court, Dr. Buchanan's suspicions were directed to the water-supply. Now, the

water-supply of the college was taken from a surrounding 5 inch main at six different places, and at one of them, namely at the Gate of Humility, there was a branch main which supplied Tree Court and no other part of the college. In short, the area of this particular water distribution was the area of the fever, and although there was no doubt that the quality of the public water-supply was good, this was no argument against a "local contamination in a local service." It had struck Dr. Buchanan at an early stage of the inquiry, that the closets in Tree Court were the only closets in the college which were not provided with cisterns, but were supplied with water direct from the high-pressure constant main; and on further inquiry the following facts were ascertained:—(1) That, according to the servants, there was occasional intermission in the constant service of water-supply; (2) that there had been two actual intermissions during the term, one of which occurred about October 25th, or a fortnight before the first case, and the other certainly on November 1st, a fortnight before the date of the second, third, and fourth attacks; and (3) that although the mains were supplied with valve-taps which were believed to prevent any regurgitation of air or water, it was clearly proved by experiment that there was a reflux of air and water into the main when the water was turned off, and that the valve-tap was useless in this particular instance for the purpose for which it was intended.

Of the closets in Tree Court, two were found to be connected directly with the water-main which supplied drinking water for the whole of the court, and it is on the structural arrangements of these

closets that the chief interest of the inquiry depends. One was situated in the basement of the porter's lodge, the other in the staircase, at an elevation of about 30 feet above the surrounding water-main, and about 5 or 6 feet above the level of the former. Both closets were of similar construction, and both were considered to have assisted in contaminating the water-supply, but from its higher elevation there was greater probability that the closet in the staircase played a much more direct part than the one on the basement. This closet was ascertained to be of the S-bend pattern, but in addition to the pipe communicating directly with the pan, there was found to be a smaller branch pipe dipping into the opening of a second S-bend, which was also connected with the soil-pipe, and which was intended to drain the "safe" of the closet in case of its being flooded. There were thus two channels through which influx of air could take place when the water-supply became intermittent, and in the case of the smaller branch there was the further possibility of liquid filth being sucked into the water-main under certain conditions. At all events, the air which thus entered "must have been essentially sewer air," and in this case the danger of such air forcing its way through traps was greatly increased by the circumstance that the sewer in the neighbouring street was unventilated, and that between the sewer and the closet there was no opening or trap of any kind connected with the excrement pipe or drain. It was further discovered that during the month of October this sewer received the discharges of patients suffering from enteric fever in other parts of the town, so that there was the probability of the sewer air having been at the time

specifically contaminated. Lastly, and this is a most significant feature of the inquiry, Dr. Buchanan thought it desirable that the smaller branch pipe, and part of the other pipe should be submitted to chemical examination, it having been observed that the end of the former was crusted over with a dirty-looking layer, and that the inside of both was lined with deposit. The analysis was accordingly made by Dr. Dupré of Westminster Hospital, who certified that the dirty-looking layer consisted of "a very large proportion of nitrogenised organic matter, and a very considerable proportion of phosphoric acid," and that he had little doubt that it was derived from "water strongly impregnated with fæcal matter." The deposit inside the pipes was of a similar character, so that, as Dr. Buchanan puts it, "Dr. Dupré's results show, first, that (as circumstantial evidence appeared to indicate) excremental matter actually had entered the water-pipes of the staircase closet, and secondly, that it had in fact (what had before been suggested as a possibility) entered the water pipes as a liquid In no other way can the presence of phosphates in those pipes be accounted for." (Mr. Simon's *Reports*, New Series, No. II.)

(6.) While there can be little doubt that this particular mode of enteric fever propagation is much more frequent than is usually suspected, the following outbreak will suffice to show the dangers which threaten any town where closets directly connected with water mains are numerous, and where the water-supply is intermittent :—During the latter half of the year 1874, an epidemic of enteric fever prevailed in the town of Lewes, of such severity that out of a population of about 11,000, nearly 500 cases had

occurred, and as many as 104 of these took place during the last week of October. Dr. Thorne, who was appointed to report upon this outbreak, discovered, after minute inquiry, that "it was due, in the first instance, to pollution of the town water-supply by water drawn from the Ouse, which receives the town sewage, but mainly spread by suction of polluting matter into the water-pipes of an intermittent water service." So soon as it became clear that the epidemic was not only favoured, but practically insured, by the intermittent water-supply, Dr. Thorne urged the necessity of a constant service, and when this was obtained the epidemic became virtually arrested. (Mr. Simon's *Reports*, New Series, No. IV.)

Although in these several epidemics there was no direct evidence to show that the outbreak depended, in the first instance, on the presence of the enteric poison in the sewage which contaminated the water, it is nevertheless noteworthy that cases of the fever were more or less common in the several localities previous to the outbreak. In the following two instances, however, investigated by Dr. C. Albutt of Leeds, and reported by him in the *British Medical Journal*, the evidence is beyond doubt, not only that the poison found its way into the drinking water, but that this was the sole cause of the outbreak. In the one case, which occurred at Ackworth, near Pontefract, in March 1870, it was found that the area of the outbreak was limited to a part of the village and school supplied by water from a certain well. The water, on analysis, gave rather more than 5 grains of organic matter, 6 of sodium chloride, and an unusual amount of nitrates and nitrites; and it was further ascertained that though

it must have been contaminated with sewage previous to the outbreak, no cases of the disease appeared until a patient was brought home to the village who was suffering from the fever. The discharges of this patient were thrown on loose ground, which drained into the water of the well.

The other instance occurred at Bramham College, Yorkshire, in March 1869. It appears that two of the pupils were laid up with enteric fever in February, but circumstances showed that they must have contracted the disease before their arrival at Bramham. Towards the end of March 19 fresh cases occurred, and all of them about the same time. This sudden outbreak clearly pointed to some common cause which must have been in operation, and it was then discovered that the well used to supply drinking water was contaminated by soakage from a soft-water tank, into which sewage matter had passed from a broken water-closet pipe. The discharges of the first two patients had also passed into this tank, and had doubtless been the cause of the outbreak. Another important fact connected with this outbreak was the distribution of the disease amongst the pupils, it being confined to those who drank water, while those who drank beer escaped. As the same water was used for cooking purposes, it would thus appear that the poison must have been destroyed by boiling.

In addition to these two instances, the following outbreaks are strongly corroborative of the view which is maintained by many that the disease is essentially a specific disease, and can only be propagated by means of a specific contagium:—

(*a.*) In 1872, an outbreak occurred at Nunney, a village near Frome, and Dr. Ballard, the Local Govern-

ment Inspector, who was sent to investigate the causes of the outbreak, thus states the conclusions deducible from his inquiry:—" 1. That the fever at Nunney was enteric; 2, that it was brought into the village from a distant place by an individual whose evacuations, and those also of others attacked in the same and in the adjoining house, found their way into the Nunney brook, at the upper part of the village; 3, that the fever spread in the village in consequence of the villagers habitually drinking the water of the brook thus contaminated, which water was still further polluted with the sewage of the village itself, containing, if not the actual excrement of the sick, yet certainly matters washed out of their soiled linen, and also more or less of their liquid evacuations; 4, that at the time of my visit, actual excrement from cases of enteric fever was finding its way into the brook at a hamlet only half-a-mile above the village of Nunney." (*Med. Times and Gazette*, 1873.)

(*b.*) The outbreak at Over Darwen, which occurred towards the close of 1874, is alike remarkable for its terrible severity, and for the thoroughness with which the cause of the outbreak was traced to its origin. According to Dr. Stevens, who was appointed by the Local Government Board to inquire into and report upon the epidemic, the first case occurred at a house some considerable distance from the town, but not very far distant from the public water-main. The patient having contracted the disease elsewhere, afterwards came home ill, and died there. On first inquiry it was stated that the water-supply could not by any possibility be polluted by the excreta from this case, but subsequent investigations rendered it only too apparent

that here lay the whole cause of the epidemic. It was discovered that the drain of the closet into which the excreta of this patient were thrown crossed the line of the water-main, and though special precautions had been taken by way of cementing and the like to prevent any leakage, it was found that the drain had become choked up, that the cement had given way, and that the contents of the drain were sucked freely, indeed regularly, into the water-main. No doubt the general filthy condition of the town greatly aided in propagating the epidemic after the specific contagium had been distributed by means of the water-supply, but the terrible rapidity with which the disease spread pointed clearly to specifically polluted water as being the prime cause of the epidemic. Out of a population of about 22,000, 2035 people were attacked within a very short period, and of these 104 died. (*Sanitary Record*, 1875.)

(*c*.) In the small village of Lausen, in Switzerland, there occurred an outbreak of enteric fever in 1871 which proved that even filtration through a considerable track of porous soil will not purify water which has once been specifically tainted. It was found, when the outbreak was investigated, that all the houses in the village, with the exception of six, were supplied with water by means of wooden pipes, from a certain spring, and that the outbreak was confined to the inhabitants who drank this spring water, the other inhabitants, who drank well-water, having entirely escaped. That the disease had been introduced by the spring-water was made clear by the following facts:—Behind the village there is a hill about 300 feet high, the westerly spur of which extends into a small side valley, and through this valley runs the Furler brook. Connected with

this brook there were the latrines of several scattered farm-houses, in one of which four persons had suffered from enteric fever in the months of June and July. Although at first sight it did not seem possible that there could be any connection between these cases and the outbreak at Lausen, it was ascertained that when the meadows in the Furler valley were watered by damming up the brook, the spring increased in amount, and that when they were thus treated in July, it yielded a turbid and bad tasting water. Not long afterwards, namely, on August 7th, 10 inhabitants were attacked, and in nine days more, 57 persons were prostrated with the disease, the number reaching to 130 at the end of October. To prove that the Furler brook could contaminate the spring at Lausen, the experiment was tried of putting common salt into the brook, when it was discovered that the spring water became quite briny. (*Deutsch. Arch. für Klin. Med.*, 1873.)

But in country districts there occur many scattered cases of enteric fever, which, although they have a water origin, cannot be traced to specifically polluted water. According to my own experience, and it accords with that of Dr. Fox of Essex, and many other health officers who have studied the etiology of enteric fever in rural districts, the disease is frequently produced by drinking water which is found to be polluted with animal matter, but not with specifically tainted matter. —As regards these cases, the most careful inquiry has failed to discover any connecting link between them and pre-existing cases, while in all of them it has been found that the well-water has been polluted by leakage from some cesspool, privy, or drain. It may be said, therefore, that though they are essentially pythogenic

they are not specific. All this, however, will be discussed more fully in a subsequent chapter (see Chap. XIV.)

3. *Dysentery.*—The instances of outbreaks of this disease which have been traced to the presence of animal impurities in drinking water are so numerous, especially in Eastern countries, that the mere mention of the fact will suffice.

4. *Diarrhœa.*—In addition to outbreaks occasioned by direct sewage contamination, there are several recorded cases of the following description:—In the Salford Jail there was a sudden outbreak of diarrhœa of a choleraic type, which affected 57 per cent of the prisoners, while of the officers and their families, who were distributed throughout the building, not one was attacked. The food of the prisoners was examined and found to be good; it was evident also that the air did not contain the cause of the disease, for both classes were under the same conditions in that respect; suspicion was therefore directed to the drinking water. It was then discovered that, though the water supplying all parts of the prison was derived from the same source, there was one cistern for the use of the officers, and another covered cistern to supply the prisoners, and that the untrapped overflow-pipe of the latter communicated with an open sewer. On the day of the outbreak the water from this cistern was observed to be coloured, and to taste unpleasantly. It had obviously absorbed sewer-gas, which had ascended through the overflow-pipe; and that this had been the real cause of the disease was confirmed by the fact that the outbreak disappeared almost as rapidly as it commenced, when the cistern was emptied and the pipe efficiently trapped. (*Second Report of the Medical Officer of the Privy Council.*)

According to my own experience, much of the diarrhœa which prevails in country districts during the summer and autumn amongst children is due to polluted water drunk either as it is drawn from the well or when mixed with milk.

Concluding Remarks.—Although an attempt has thus been made to classify roughly the hurtful impurities of water, and the diseases which they may severally produce, it need hardly be said that in the great majority of instances of faulty sanitation connected with water-supply, there is often a combination of impurities and of diseases both. For example, the analysis of waters which have proved to be decidedly injurious shows that in general the impurities are numerous; and, on the other hand, not one but several diseases may be either directly produced or indirectly influenced by them. And this difficulty of apportionating to special impurities their special effects is frequently increased by the presence of other causes of disease. Thus, the water may not only be polluted, but the supply may be scanty; and thereby give rise to great want of cleanliness of the person, of clothes, of cooking utensils, and of the general surroundings; while overcrowding, defective sewage-removal, badly ventilated drains, and other causes of disease, may also co-operate in seriously affecting the health of a community and largely increasing the death-rate.

Amongst other diseases which have frequently a water origin may be mentioned diphtheria, ulcerated sore throat, low fever, and erysipelas. Indeed, in purely country districts what is known as low fever is essentially a filth fever, and is found to be produced

in the great majority of instances by polluted well water.

It would also appear that the prevalence of calculous disease and gravel bears a close relation to the amount of lime and magnesian salts contained in the drinking water of certain parts of the country. This disputed subject has been carefully investigated by Dr. Murray of Newcastle-upon-Tyne (*Brit. Med. Journal*, 1872); and his statements, together with the cases which he adduces, are strongly corroborative of this view.

Finally, it has to be noted that several of the entozoa find their way into the body of the agency of drinking water, as for instance the *Bothriocephalus latus* and the *Ascaris lumbricoides*. The latter, which is known as the *round* worm, I have found to be very common in districts where the water supply is chiefly obtained from shallow dip wells.

CHAPTER IX.

DWELLINGS.

THE vast importance attaching to the sanitary conditions of dwellings has already been frequently alluded to in previous chapters. Diseases arising from unhealthy site, from insufficient ventilation or overcrowding, from tainted or stinted water-supply, from defective drainage, or from accumulations of filth, are all of them associated with habitations which are faulty in their situation, construction, or management.

SECTION I.—SITE.

In choosing a site, special attention should be paid to the nature of the soil and the general conformation of the ground. The soil, if not dry, should be drained, and all hollows wherein water is likely to lodge should be avoided. Where possible, the aspect should be open and cheerful, so that an abundance of light and a free movement of air can be obtained.

In towns, a great evil sometimes arises from building on rubbish containing vegetable matter which has been used to fill up the excavations made in brickmaking. Thus, in 1872, Mr. Crossby reported that the high rate of mortality in Leicester during the autumnal months was chiefly due to an annual visitation of infantile diarrhœa which prevailed in parts of

the town built on such refuse; and he distinctly attributed the disease to this cause. It is also worthy of special notice, that this opinion has recently been fully corroborated by the very elaborate and painstaking report presented by Dr. Buck and Mr. Franklin on the epidemic of diarrhœa which prevailed in that town during the summer and autumn of 1875. Further, the evidence of Drs. Parkes and Sanderson, in their valuable report on the sanitary condition of Liverpool, though negative as regards the effects of cinder-refuse on the health of the occupants of houses built upon it, clearly points to the conclusion that such a soil is objectionable, at any rate when first laid down. With regard to this point, they advised the Town-Council to adopt the following rules:—

"1. No excavation should be used for the reception of cinder-refuse unless it is efficiently drained. This appears to us to be of especial importance in relation to the filling up of brickfields. It is well known that the whole of the surface of clay is never removed, and there is always sufficient to form an impermeable basin, in which, in the absence of drainage, water constantly collects. We hold it to be of the greatest importance, for the rapid decomposition of whatever offensive material may exist in the 'cinder,' that it should be able to become dry. The only way in which this can be promoted or secured is by efficient subsoil drainage.

"2. As the vegetable and animal matter contained in the cinder-refuse decays and disappears in about three years, and is virtually innocuous before that time, we recommend that places filled up with cinder-refuse shall not be built upon for at least two years from the date of last deposit."

They also advised that road-scrapings should not be mixed with the cinder-refuse, and that the scavenging department should be more careful with regard to the selection of material.

It need hardly be said that wells sunk in made-up soils of this description can only yield a water which is highly polluted and altogether unfit for use.

SECTION II.—STRUCTURAL ARRANGEMENTS.

In building on a site which has already been occupied, great care should be taken to make a thorough examination of the ground, so that no cesspits, rubble drains, or old wells, may escape notice. Every old drain should be taken up, all removable filth cleared away, and every pit thoroughly cleaned out and filled in with concrete.

Unless absolutely necessary, no drain should traverse the basement of a house; and when it is necessary, as when houses are joined together in streets or squares, every such drain should be made absolutely air and water tight. Pipes of glazed earthernware are best suited for the purpose. They should be laid on a bed of concrete made with ground lime or cement, securely jointed, and covered with concrete. They should also be provided with full means of ventilation at either side of the basement. When they pass through foundation walls it is advisable that relieving arches should be turned over them, because it often happens that they become broken by settlements, or during the consequent underpinning. Outside the building the pipes should be laid in a water-tight trench of clay puddle or concrete, and should lie their full diameters below the sub-

soil of the basement, in order that the lowest parts of the house may be efficiently drained.

To facilitate inspection, the outside track should be provided, at suitable intervals, with access pipes. These are of various patterns, but all of them permit an easy opening into the drain, so that deposits or obstructions can be readily removed. To prevent the formation of such deposits, all house drains should be regularly flushed. (For further particulars, see Chapter on Removal of Sewage.)

Where a cesspool is required to receive the sewage of a country house provided with water-closets, it should be situated at a safe distance from the building, made perfectly water-tight, and be abundantly ventilated. The plan of construction should be on the liquid-manure tank principle, the walls being of brick-work set in cement, surrounded by a clay puddle, and lined inside with a coating of cement. Both roof and bottom should be arched, the roof provided with a manhole, and the bottom built with a fall towards one end, where a pump could be fixed. The depth should not exceed 6 or 7 feet, otherwise the increased hydrostatic pressure would necessitate expensive walling. To separate the solids from the liquids, a galvanised iron wire diaphragm or grating should divide the tank into two parts. All cesspools should be regularly and frequently cleaned out, and it is of the utmost importance that the drains should be trapped, and the soil-pipe ventilated.

If the water-supply is to be derived from a well, the well and cesspool should be widely separated. In case of accidental leakage, it is also necessary that the well should not be near the house drains. To exclude

subsoil water, the upper part of a well should be clay-puddled, or made otherwise water-tight, and the mouth should be protected against the entrance of surface water.

After having secured dryness and healthiness of subsoil, the next point of importance which has to be kept in view is the isolation of the area upon which the proposed dwelling is to be erected from the subsoil, and this can be effected in the cheapest and best way by using concrete. In order to prevent damp from rising into the walls, a damp-proof course should overlay the whole of the foundations. Two or three courses of slate laid in the best cement will answer the purpose, or, if external symmetry in the damp-proof course be made a desideratum, tiles made of highly vitrified stoneware should be employed. When there is a basement storey, it should be isolated from the ground by an open space. The entrance of underground damp may also be prevented by constructing what are called dry areas; that is, by leaving a space between the main wall and a thin outer wall, which reaches to the ground level, the two being joined together here and there by stretching bricks.

As much of the dampness in walls is due to driving wet, well-planned houses are now often built with hollow walls, in which case ties or bonding bricks must be laid in at regular intervals, to render the strength and stability of the twin walls equivalent to a strong single wall. With single walls, built of soft porous material, the effects of driving wet may be obviated by slating or tiling them, or by applying to the outer surface one or other of the several patent waterproof compositions which are well recommended.

Perforated bricks should be introduced at suitable distances in the outer walls, to admit air to the joists and beneath the flooring.

One of the gravest faults in the construction of even the better class of houses in the present day is the little attention which is paid to the position and arrangements of water-closets. They are too frequently situated in out-of-the-way corners, where only borrowed light can be obtained, and efficient ventilation is impossible. The best position is in an isolated block, built tower-fashion, and abutting against the outer wall of the house, with a closet on each floor and the supply cistern on the top. There should be an anteroom or passage between each closet and the house, large enough to admit of sufficient cross ventilation by means of open windows, or windows provided with ventilating panes. A double set of doors would be required,—one leading into the house and the other cutting off the passage from the closet. The closet-seat should face a window in the outer wall, so that abundance of light may be secured for inspection with regard to cleanliness, and direct draught from the window be avoided. The window should extend up to the ceiling, and have double sashes. The closet may be permanently ventilated by keeping the top sash drawn down, or by air-bricks inserted immediately beneath the ceiling. In smaller-sized houses the closet may be simply projected from the building, with the seat facing the door, and with two opposite windows reaching to the ceiling between the seat and door. Cross ventilation and sufficient light would thus be obtained, without the interposition of an anteroom.

There are so many kinds of closets, well arranged in all their details, that it is difficult to say which of them

are most to be recommended. There are others, again, such as the round hopper closet-pan fixed into an ordinary sigmoidal bend, which cannot be sufficiently condemned, unless worked by a very high pressure of water;—they are constantly getting foul, and it is seldom that the whole of the excreta are removed. Generally speaking, those closets are the best which provide for good flushing and rapid and complete removal of the excreta, without permitting reflux of foul air. Every closet, unless it be flushed by hand, should be provided with a cistern, preferably of the waste-preventing kind, because it is of the utmost importance that there should be no direct communication with the water main. It has also to be pointed out that the closet should not be supplied from the same cistern which supplies the drinking water. The pan should be roomy and made of white glazed earthenware; the machinery should work easily and not be apt to get out of gear; and the seat should be so framed as to come asunder readily to permit of inspection. Amongst closets which have been found to work satisfactorily may be mentioned the "Holborn Closet" and "Universal Closet," both manufactured by Mr. Finch of the Holborn Sanitary Works; the "Patent Valve-Closet and Trap" of Mr. Jennings; the "Elastic Valve-Closet;" "Underhay's Regulator Valve-Closet;" and Banner's Closet.

As soil-pipes communicate directly with the drains, they should be carried up to the highest part of the roof, and be of the same diameter throughout. Efficient ventilation of the drains is in this way secured at a most important point, and the pipe from the closet trap can be connected with the soil-pipe without interfering

with the upward current of sewer-air. If the soil-pipe cannot be carried straight up to the top of the house, the bends or angles should be made as obtuse as possible, and in any case it should not be plastered or built into the wall, but left free for inspection throughout its whole track. It is obvious that, were this plan universally adopted, there could be no pressure of sewer-gas against the closet trap, and therefore little or no risk of its entering into the house by this channel.

It has been urged, by way of objection against this plan, that, where houses are closely packed together, and are of different elevations, the sewer-gases discharged from the pipes of the lower houses would find their way into the higher, and thus become not only a nuisance but a source of danger. With ample sewer-ventilation, however, the objection does not hold good, because the sewer-air is so diluted as to be inoffensive and comparatively pure; besides, in cases where it is proved to be offensive, some such mutual arrangements as are adopted with regard to offensive chimneys would meet the difficulty.

With regard to all other pipes, whether waste-water pipes, sink-pipes, or pipes from lavatories, it should be laid down as a rule that none of them should lead directly into either the soil-pipe or drain. They should be carried outside the house to within 12 or 18 inches from the ground, and deliver on to the grating of a yard or gulley trap. Such a trap might be ventilated by the rain-water pipe when the rain-water is allowed to flow into the drain, or through a charcoal tray, if it become offensive. But although the sewer-gases are in this way prevented from entering the house, it is still necessary that the sink and other pipes should be

trapped. Scullery and sink pipes, for example, will require article-intercepting traps, and pipes to lavatories or baths must be provided with syphon traps to prevent the ingress of cold air.

All traps on house-drains should be ventilated either by pipes carried to the roof or parapet of the house, or by what is called direct ventilation. Unless protected in some such way, they are comparatively useless. (See Chap. XI.)

Details concerning the ventilation and warming of a house have already been given in Chapter IV., and the only points which need be repeated are—the importance of constructing a separate extraction flue for each room in the chimney-stack, the desirability of inserting ventilating fire-places, and the great advantage of securing that the products of gas-combustion be conveyed by special channels into the outer air.

It is needless to say that the rooms in a well-constructed and healthy house should be spacious, airy, and light. The windows should reach to within a short distance of the ceiling, and should always be made to open. It is preferable to have them glazed with plate glass, to economise heat. No single bedroom should be of less dimensions than 1000 cubic feet, nor should any bedstead be fixed in a recess.

Section III.—Dwellings for the Poorer Classes.

In constructing buildings for the poorer classes, the great difficulty, encountered at the very outset, consists in providing the necessary accommodation with the requisite sanitary arrangements at a cost which will allow of a sufficiently low rental. In towns the original cost

is greatly increased by the high price of land, but even in country places, where a site can be procured at a cheap rate, the cost for the erection of a cottage of the humblest pretensions will entail a rental which many a labouring man can barely meet. Where the ground rental is low, the cheapest and most commodious form of labourer's cottage is one without any upper storey. Thus, according to Mr. Allen, in his manual on Cottage Building, a cottage consisting of a living-room for general every-day use, a bedroom for the labourer and his wife, a bedroom for boys, a bedroom for girls, a small wash-house, a store-room, and closet, could be built for £100, provided all the rooms are on the ground-floor, and that two such cottages be ranged side by side, so as to be spanned by the same roof, and contained within four walls, forming a simple parallelogram. The row of cottages proposed by Dr. Hunter in the Seventh Report of the Medical Officer to the Privy Council, provided for a front and back kitchen in each cottage, and two bedrooms overhead. The kitchens were to be paved with brick or tile, "the front about 11 feet by 11, by 8 feet 6 in. high; the back about 11 by 8 feet 6 in. Ceiling would be unnecessary. There should be five doors only, the closet under the stairs one, each bedroom one, and two house doors. There should be four sliding windows, a grate with an oven, a boiler in the back kitchen, a little fireplace in one bedroom, and a Welsh slate roof, the bedrooms being ceiled.

"Such houses might be supplied for £50, or £1500 for the thirty."

In a paper read before the Farmers' Club in 1874, Mr. Howard of Bedford states that, some few years previously, he built a block of six cottages for his

labourers entirely of concrete. The walls were a foot thick, and in consequence of the impervious nature of the material they were warmer and drier than ordinary brick-work. Each cottage contained three bedrooms, and each was provided with an earth-closet at the end, but accessible from within. Exclusive of the closets, the cost of the whole block was a little over £600, or £100 per cottage.

According to the design by Mr. Birch, which obtained the award of the Society of Arts in 1864 for premiums offered by Mr. Bailey Denton, the estimated cost of a pair of cottages was £203, including every requisite necessary to render them complete and fit for occupation. On the ground-floor it was proposed that there should be a living room 12 feet 6 in. by 12 feet; a scullery containing a copper for washing, and a sink, 10 feet 5 in. by 7 feet 6 in; and a small pantry and place for fuel opening into the scullery. On the chamber floor there were to be three bedrooms with a floor-space respectively of 12 feet 8 in. by 8 feet 6 in.; 7 feet 8 in. by 8 feet 6 in; and 9 feet by 8 feet. (See *Builder*, 1864.)

Owing to the increased cost of materials and the rise in wages, it is very likely that the above estimates would be found to be somewhat too low for the erection of similar cottages in the present day, but if built in blocks or pairs, I am credibly informed that good cottages with three bedrooms can still be erected for about £100.

In these plans, and in fact in almost all plans for cottage construction, the cubic space allowance is very limited, so that overcrowding, to a greater or less extent, is sure to prevail at times. Cottages which are scarcely

roomy enough for a married couple and two or three children become occupied by much larger families, or the family increases in number year after year, while the bedroom accommodation remains the same. The initial space, therefore, should be ample enough to meet the requirements of, at any rate, moderate family increase; and when a number of such cottages are built in the same locality, they should be of different sizes, to suit small and large families alike. The kind of closet best suited for country cottages is some modification of the dry system, while the slops, if they do not discharge into village drains, should be utilised in the garden, or disposed of by subsoil irrigation where that is possible. All this, however, will be discussed more fully in Chap. XI.

In large towns the house accommodation for the labouring classes must necessarily be supplied in a great measure by what are called tenements. The following is a copy of the bye-laws sanctioned by the Treasury in 1867 for this class of dwellings, built from loans under the Labouring Classes' Dwellings Act 1866:—

"Separate water-closet accommodation to be provided for each tenement, or else, where water-closet accommodation is to be used in common by the occupants of two or more tenements, separate accommodation must be provided for each sex. Such accommodation may be either water-closet, earth-closet, or privy.

"Each tenement to have a dust-bin, or the use of a dust-bin common to several buildings.

"Each tenement to be well lighted by external windows made to open.

"Each tenement to have ready access to water.

"Where several tenements in one building, proper

ventilation to be provided for the passages, staircases, etc.

"The drains to be well constructed.

"Parties to whom moneys to be advanced to enter into covenants with the Public Works Loan Commissioners,—That where there are several tenements in one building, they

"(*a*) Will cause the passages, staircases, etc., to be kept clean.

"(*b*) Will cause the water-closets, etc., to be kept in good order.

"(*c*) Will cause the dust-bins to be emptied at intervals of seven days.

"(*d*) Will take precautions against any interruptions in the supply of water.

"(*e*) Will keep the windows in good order and repair, and the chimneys swept.

"(*f*) Will keep the drains in proper order.

"(*g*) Will allow inspection by Commissioners of Works, to see that the above covenants are observed.

"Number of cubic feet in each room of the several classes of tenements for which money has been authorised to be advanced:"—

	One room of cubic feet.	One room of cubic feet.	One room of cubic feet.	One room of cubic feet.	One room of cubic feet.
Class I. of two rooms	715	1219	—	—	—
Do.	816	994	—	—	—
Do.	995	1020	—	—	—
Class II. of four rooms	960	960	960	960	—
Class III. of five rooms	372	675	1056	1656	1232
Do.	446	459	459	781	1468

Of equal importance with the construction of dwell-

ings for the labouring classes is the far more difficult problem of repairing and improving the unhealthy abodes which, in town and country village alike, increase the annual rate of mortality to an extent that can hardly be estimated. It is true that the law already prohibits the inhabitation of the worst class of dwellings, such as damp, dark, underground cellars; but there are other dwellings, so numerous that their immediate demolition would deprive a large proportion of the lower classes of shelter, which no alterations or improvements can render healthy. They are either situated in narrow, dingy alleys, or huddled together in close courts, so as to be practically unventilable, or their internal condition and constructural faults are so grave as to be beyond remedy. Nor are these the only sanitary defects connected with them which have to be condemned. It is in these very dwellings that the filth and poisonous effluvia due to overcrowding are constantly accumulating, and where the germs of disease find a fitting soil for their development. The departmental reports of the Privy Council afford numerous instances of such a state of things, and notably those of Drs. Hunter, Stevens, and Buchanan.

No doubt the carrying out of the provisions of the Artisans' Dwellings Act of 1875 will eventually bring about a marked improvement in this respect in many of our cities and large towns, for hitherto the difficulty of dealing with what is called "surface-crowding" has thrown great obstacles in the way of reaping to the full extent the advantages to be gained from lessening the indoor over-crowding. In the worst parts of Liverpool, according to Drs. Parkes and Sanderson, nearly 1000 persons are huddled together in one acre of ground, and

in other towns, such as Glasgow and Greenock, the number per acre in some districts is quite as great. It is clear therefore that no improvement in the dwellings, nor any increase in the amount of cubic space per head, will render the ventilation as satisfactory as it should be, when so many houses are packed together in such a limited space. Demolition of old houses, the displacement of the population into blocks of model dwellings, or into houses put into serviceable repair, and the opening of new streets, are all necessary.

In country districts, where there is far less excuse for the existence of these evils, it has been found that in reality they are almost as glaring and wide-spread as in towns. The elaborate report of Dr. Hunter on the State of the Dwellings of Rural Labourers (see *Seventh Report of Medical Officer of Privy Council*) may be quoted in proof of this statement. In all, 5375 cottages were reported upon. Of these, 2195 contained only one bedroom; 2930 contained two; and only 250 more than two. The number of persons resident in them, including adults and children, was 24,770, giving an average of 4·6 persons to a house, or 2·8 to a bedroom. In the single-bedroomed houses, the average number sleeping in the bedroom was 4, 2·2 of whom were adults and 1·8 children. The average cubic space for sleeping accommodation was estimated at 156 feet per head. The rickety state of the great majority of the hovels permitted a freer interchange of air than in the new cottages, so that, although the cubic space per head in the latter was somewhat larger, the contained air was generally more impure. Indeed, many of the bedrooms were so much exposed to the weather, that cases of sickness, when they did occur, had to be treated

in the kitchen. But the wretched sanitary condition of the dwellings was even a less evil than their numerical insufficiency. It was found that many landlords pulled down the cots on their estates when they fell into decay, without providing others, and thus forced the labourers to find house-room in already overcrowded hamlets. As a consequence, this huddling together of human beings not only presented numerous *foci* for the development of disease, but rendered the limitation of any contagious diseases which were introduced an almost hopeless task. That such a state of things continues to exist in many rural districts, the reports of medical officers of health from all parts of the country show but too clearly, and though there can be no doubt that the improvements which have been carried out in various districts since the passing of the Public Health Act of 1872 have been very considerable, it is impossible to cope with the innumerable evils connected with defective house-accommodation in small towns and country villages, until larger legislative powers are conceded. As I have stated elsewhere, I am strongly of opinion that some measure akin to the recent Artisans' Dwellings Act is urgently required for rural and small urban districts. "Let this legislative necessity be advocated as warmly as it has hitherto been tacitly admitted, and there will be no difficulty in drawing up a bill which, without unfairly interfering with the rights of private property, will give a wholesome stimulus to the discharge of public obligations; afford the requisite scope for individual or conjoint enterprise in adapting old cottages and in building new ones where they are required; and, above all, empower and impose it as a duty on sanitary authorities which cannot be evaded,

that they themselves shall carry out the necessary improvements in localities where private or conjoint enterprise, aided if you like by philanthropic effort, may prove inadequate, or where public obligations on the part of landowners are in this respect persistently neglected. But it has been urged that individual or conjoint enterprise will fail to be elicited because cottage property does not pay a sufficient percentage on the outlay. Well, I am quite willing to admit that what are called ornamental cottages may not pay, but ornamental cottages are needlessly expensive, and are built under exceptional circumstances. What I do know is this, that substantial and comfortable cottages can be built in pairs or in blocks, each containing three bedrooms, at a cost of about £100 per cottage. Then, again, it is very well known that the worst class of cottages when they get into the hands of small property owners often pay as much as ten to fifteen per cent on their outlay, so that taking into consideration the improved and improving position of the labourer to pay a better rental, the fair return that may even now be obtained for new cottages, and the comparatively large return which is obtained for all cottages after being put into habitable repair, there is every reason to believe that there will be no lack of private or public enterprise in the shape of local building and improving societies, provided only the requisite facilities for such enterprise be legalised by Act of Parliament." (See the Author's pamphlet on *Sanitary Defects in Rural Districts, and How to Remedy them,* and Dr. Bond's *Home of the Agricultural Labourer.*)

Unfortunately too, many of the evils connected

with house-accommodation in rural districts threaten to become perpetuated, inasmuch as rural sanitary authorities, unless they apply specially for urban powers, have no control over the erection of new buildings. Similar bye-laws should be in force with respect to thickness of walls, height of rooms, ventilation, drainage, and general sanitary arrangements, which are carried out in urban districts. Indeed it is difficult to conceive why such control should not have been conceded to sanitary authorities without distinction, unless it be that sanitary legislation has hitherto been halting and one-sided. It is quite true that many sanitary defects connected with existing cottages can be dealt with under the wide term *nuisance;* such as—the repair of uneven floors, and roofs that let in the rain; the repair of dilapidated walls; the opening of closed windows; the removal of privies and pig-styes which abut against outside walls; the drying of the subsoil; the repair of drains; and the like. It is likewise true that if a house cannot be put into fairly habitable repair the law gives power to close it; but where houses are scarce, it need hardly be said that this becomes a very serious matter, inasmuch as it either tends to increase the overcrowding elsewhere, or leads to displacement of labourers and their families, an alternative which is attended at all times with much inconvenience, and very frequently with great hardship.

In large towns this displacement of the population becomes a question which naturally affects the poorer classes to a much greater extent than in country villages. Many extensive undertakings, such as the construction of railways and new streets, while they

act beneficially in making wide clearances in the crowded districts, almost of necessity conduce to overcrowding in neighbouring parts. The families that are thus rendered homeless by the demolition of their dwellings seek the nearest shelter, rents are raised in consequence of the increased demand for accommodation, and such as cannot afford to expend more than they did previously must be contented with homes even less healthy than those which they have been compelled to leave. As a compensating measure, the running of working men's trains morning and evening, between the suburbs and the town stations, although it is a step in the right direction, does not by any means meet the difficulty. Larger measures are undoubtedly required, and the more thoughtful amongst sanitary reformers are agreed in maintaining that no parliamentary powers, permitting the demolition of numerous dwellings in populous districts, should be granted unless the companies or corporations applying for these powers provide commensurate and improved accommodation elsewhere, and within reasonable distances. It is true that many of the displaced population might not choose to remove to the new dwellings, but they should have the option. Tenants, at all events, would not be wanting, and that there would be no financial loss is clearly proved by the profits gained by private enterprise in building homes for the working-classes, although it must be admitted that numbers of such houses, as they are run up in the present day, can scarcely be pronounced habitable. Urban sanitary authorities have, however, full powers vested in them by the statutes to prevent the erection of dwellings that are unwholesome,

and it is their duty to see that the accommodation and structural arrangements are in all cases satisfactory.

Concerning the duties of the medical officer of health with regard to overcrowding and places unfit for habitation, together with the sanitary enactments dealing with the same, see Chapter XVI.

CHAPTER X.

HOSPITALS.

In large towns the position of every hospital must primarily depend on the distribution of the population, or part of the population, whose wants it is intended to relieve, and hence the choice with regard to site is often very limited. Apart, however, from this restriction, there are certain considerations which ought always to influence the selection of site. For example, the future hospital should be erected in as airy and open a space as can be obtained, preference being given either to the outskirts of towns or to their largest interior unoccupied spaces. According to the recommendations of the Chirurgical Society of Paris in 1864, a free area of not less than 540 superficial feet should be allowed for each patient. This would give an acre of ground for a hospital containing 80 beds. In this country, on the other hand, an acre for 100 patients has been held to be sufficient. Any defect in salubrity of site must be compensated by increased floor and cubic space.

No doubt, the most healthy site for a hospital is in the open country, with a dry and porous soil, and slightly raised above the plain to facilitate drainage, but even a stiff clayey soil can be made perfectly healthy if proper precautions be taken in asphalting or concreting the foundations, and in providing plenty of free ventila-

tion beneath the ground-floors. While shelter from the cold north-easterly winds is desirable, it is an error to build hospitals on the face of a steep slope, or in any situation where there is an impediment to a free circulation of the air. Undrained marshy ground should be avoided, nor should houses or clumps of trees be in close proximity to the building.

For hospitals situated in the crowded localities of large towns, convalescent homes in the country, or at the sea-side, are now being provided, and with marked advantage to the patients.

The late discussions on hospitalism, though perhaps somewhat one-sided in giving such prominence to the test of surgical results, have fully established the great hygienic advantages which small cottage hospitals possess over the large palatial buildings that have hitherto found favour with the profession. It is further generally admitted that, when large hospitals are rendered necessary, they should approximate as much as possible to the sanitary conditions which can only be ensured by small detached buildings. The application of this principle has resulted in the construction of hospitals on the pavilion system—a system which accommodates itself to almost any site and to any number of patients.

SECTION I.—PAVILION HOSPITALS.

In this description of hospital, each pavilion may be regarded as a separate hospital, and the impurities of every single ward are cut off from the other wards. The pavilions are united by a corridor for administrative purposes and for convenience, but are so arranged that a free circulation of air can always take place between

them. In its simplest form a pavilion would consist of a single ward, with the necessary additions for administration. More frequently, however, it consists of two wards, one above the other, and, in some instances, of three wards, as in the Marine Hospital at Woolwich.

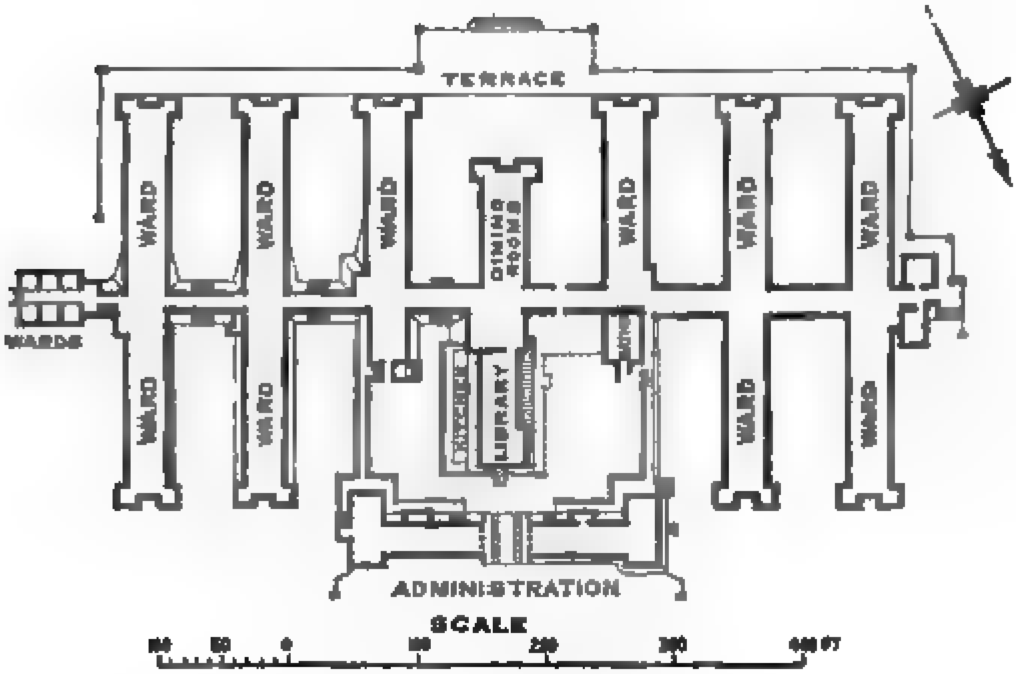

Fig. 5.—GENERAL PLAN OF HERBERT HOSPITAL, WOOLWICH.
(From "Construction of Hospitals," by Douglas Galton.)

Three-storeyed pavilions are objectionable, because their height necessitates a lofty corridor to unite them, and induces stagnation of the air. With two-storeyed pavilions, on the other hand, the corridor need only be

Fig. 6.—Sketch of the end of the southern Pavilions of Herbert Hospital, showing the elevation of the corridor. (After GALTON.)

half the height of the pavilions. In large hospitals, such as the Herbert Hospital, the pavilions may be

united in twos, end to end, with the corridor running between them, the staircase being, as it were, strung on to the corridor. The distance between the pavilions should be at least twice their height.

The basis or unit of hospital construction is the ward. The conditions which determine the size and form of a ward are the following:—

1. The number of patients which it should contain.
2. The floor and cubic space allowed to each patient.
3. The arrangements for warming, light, ventilation, and nursing.

1. The number of patients in a ward will depend on the size of the hospital, and, occasionally, on the nature of the cases. A cottage hospital, for example, will necessarily consist of small wards, and even in large hospitals small wards are required for isolating very severe or special cases. With these exceptions, however, the number of patients in a ward must depend mainly upon the number which can be efficiently nursed at the smallest cost per head. Miss Nightingale, in the Report on Metropolitan Workhouses, fixes this number at 32. She says, "a head nurse can efficiently supervise, a night nurse can carefully watch, 32 beds in one ward, whereas, with 32 beds in four wards, it is quite impossible." Throughout European hospitals the number varies from 24 to 32.

2. One of the most important questions attaching to hospital construction is the amount of floor and cubic space which should be allowed to each patient, and there is scarcely any question concerning which there has been so much discrepancy of opinion. Thus, Dr. Todd maintained that 500 cubic feet were sufficient; Dr. Burrows, 1000; the Army Sanitary Commission,

1200; and the Committee appointed to consider the cubic space of Metropolitan Workhouses, 850. The recommendations of this Committee further limited the cubic space allowance for dormitories to a minimum of 300 feet, and for wards containing infirm paupers to a minimum of 500 feet per head. There is no doubt, however, that, in consequence of the conflicting evidence on which the Committee had to base its recommendations, the difficulties of efficiently ventilating small spaces without draught were not sufficiently appreciated; but as reference has already been made with regard to this point, it need not be again discussed. Suffice it to say that General Morin, the greatest French authority on ventilation, to whom the disputed subject was submitted, gave it as his opinion that, even for paupers who are not ill, he considered it "necessary not to descend below 880 cubic feet of space, and besides this the condition must be imposed of renewing the air in the proportion of 1060 cubic feet per individual per hour."

That the recommendations of the Committee failed in securing purity of the air in workhouses, is shown in the reports on night-nursing which appeared in *The Lancet* in 1871. With regard to the Holborn Workhouse, for example, the report states that "there are upwards of 200 sick paupers here, of whom the great majority are unable to leave their beds. There are 240 deaths in the year, or an average of 5 per week. The wards are low, close almost to offensiveness, and overcrowded; although they may be an improvement on the style of thing which was in vogue twenty years ago, they nevertheless cut a sorry figure when compared with even the worst-built of our general hospitals."

And again, with regard to the Marylebone Workhouse:—"The amount of cubic space varies from 300 to 1200 feet. In some of the wards the beds absolutely touch, and there is scarcely room to thread one's way between the rows. The atmosphere in these wards is, as may readily be imagined, anything but nice. It is true, the inmates of them are comparatively healthy, but we should think that the arrangements are well calculated to rob them of what health they have."

For ordinary hospital cases it is now generally admitted that a cubic space of at least 1200 feet should be allowed per patient, and for cases of infectious disease, or for severe surgical cases, as much as 4000, and it may be doubted if this be sufficient at all times.

On the superficial area per bed will depend the distance between the beds, the facilities for nursing, and the conveniences for ward administration. This, like the cubic space, has been variously estimated. Thus, in St. George's Hospital it is only 69 square feet; in St. Bartholomew's it is 79; in the Herbert Hospital, 99; in the Netley Hospital, 103; in Guy's, 138; and in the new St. Thomas's Hospital, 112. For all nursing purposes, Miss Nightingale maintains that at least 90 square feet should be allowed per bed, and this amount, according to Captain Galton, should be accepted as a minimum. Where medical schools are attached to hospitals, an extra allowance must be allotted for the requirements of clinical teaching. The space must also be greatly increased in fever or lying-in wards. The height of an average-sized ward should be 13 or 14 feet.

3. For providing sufficient light and for maintaining purity of the air, much depends on the width of the ward. Experience has shown that this should not be

less than 24 feet, and not more than 30 or 35. In the new Leeds Hospital it is 27 feet 6 inches; in the new St. Thomas's 28 feet; and in the Herbert Hospital 26.

The ventilation of each ward should be entirely independent of the others, and to effect this, cross-ventilation by means of open windows, aided by Sheringham valves, extraction-flues, and ventilating fireplaces, is deemed to be the most efficient. In the summer months, when fires are not required, the windows should always be kept more or less open, except during rough blustering weather.

When a window is allowed for each bed, which is sometimes the case, the wall-space between the windows should be six or eight inches wider than the bed. In the pavilion system, however, an allowance of one window for every two beds is generally considered sufficient, the beds being arranged in pairs between the windows, and separated from each other by a distance of at least three feet. The windows should reach from within two feet or two feet six inches from the floor to within one foot from the ceiling. The space between the end wall and the first window on either side of the ward should be four feet six inches, and the space between the adjacent windows nine feet, the windows themselves being four feet six inches wide. An end window to a long ward adds greatly to its cheerfulness, and aids materially in the ventilation of the ward. The ordinary sash window, made to open at top and bottom, is perhaps preferable to any other kind. To economise heat plate-glass should be used instead of ordinary glass.

In addition to means of ventilation provided by

windows, there should be a fresh-air inlet, furnished with a Sheringham valve, placed near the ceiling and between each window, or an upright ventilating tube of the kind recommended by Mr. Tobin. When the fire-places are situated in the external walls, two or three fresh-air inlets may be provided at equal distances along the centre of the floor, and communicating by means of transverse flues beneath the flooring with the external air. Such inlets are so far removed from the beds that the currents entering through them are not felt by the patients when in bed, and they could be closed if deemed necessary during the day-time. The gratings covering them should be capable of easy removal, so that the flues may be cleaned out regularly.

The extraction-flues should be situated, if possible, on the same side of the ward as the fire-places, and should be carried above the roof and louvered. When not contiguous with a chimney, they should be provided with gas-jets to aid their extractive power. If the fire-places are situated in the centre of the ward, the extraction-flues should be placed in the opposite corners. The inlets to extraction-flues ought to be near the ceiling, but not in close proximity to the fresh-air inlets.

The fire-places best suited for infirmary wards are the ventilating stoves already described in the Chapter on Ventilation. But in addition to these, or in place of them, the fresh air might also be heated by hot-water pipes, coiled in boxes below each bed, as recommended by Dr. Parkes, or the pipes might pass along behind the skirting, the skirting being perforated or supplied with gratings opposite each bed, for the admission of the heated air.

Every gas-jet in a ward should be furnished with a

bottomless lantern communicating with an extraction-tube to carry off the products of combustion, or Rickett's ventilating globe lights should be used. (For particulars with regard to ventilation, see Chapter on that subject.)

The furniture in a ward ought always to be reduced to a minimum, and should never be cumbrous or bulky. Iron bedsteads are to be preferred to wooden ones, and thin horse-hair mattresses, placed on springs, to thick flock or woollen mattresses. All bedsteads should be ranged at a short distance from the walls. Coverlets and blankets should be white or light-coloured, to show dirt, and ought to be frequently aired.

The other points of sanitary importance connected with a ward are its offices, and the materials employed in construction.

Ward-offices are required for facilitating nursing, and for the direct use of the sick. Thus every ward should have attached to it, at the end nearest the door, a scullery and a nurse's room, and, at the farther end, a water-closet and ablution-room. The nurse's room should be light and airy, and large enough to be used as a bedroom. It should also be provided with a window, looking into the ward, for purposes of inspection. The scullery should be situated opposite the nurse's room, and ought to be fitted with a small range for warming drinks, preparing fomentations, etc.; a sink with hot and cold water laid on; and shelves and racks for dishes. It should be large enough for the assistant nurses to take their meals in.

The water-closet and ablution-room should be situated, one at either farther corner of the ward, and both should be completely cut off by means of swing-doors

and a lobby supplied with cross-ventilation from the ward. The water-closet apartment ought to contain one closet for every 10 beds, or 3 closets for 32, and should also be supplied with a sink and a urinal. Instead of a handle and plug for turning on the water for flushing, it is preferable to have a self-acting water-supply connected with the door, because some patients are careless, and others are too feeble to raise the handle.

The ablution-room should contain a plunge-bath with hot and cold water laid on, a shower-bath overhanging the broad end of the plunge-bath, and a lavatory table fitted with basins, and also supplied with hot and cold water. There should likewise be room enough to contain a portable bath on wheels, a hip-bath, and a foot-bath for the use of patients more or less bedridden. The pipes leading from the sink and lavatory table should not be boxed in, because the spaces thus enclosed become receptacles for dirt.

The supply of water should be ample, and the drain-

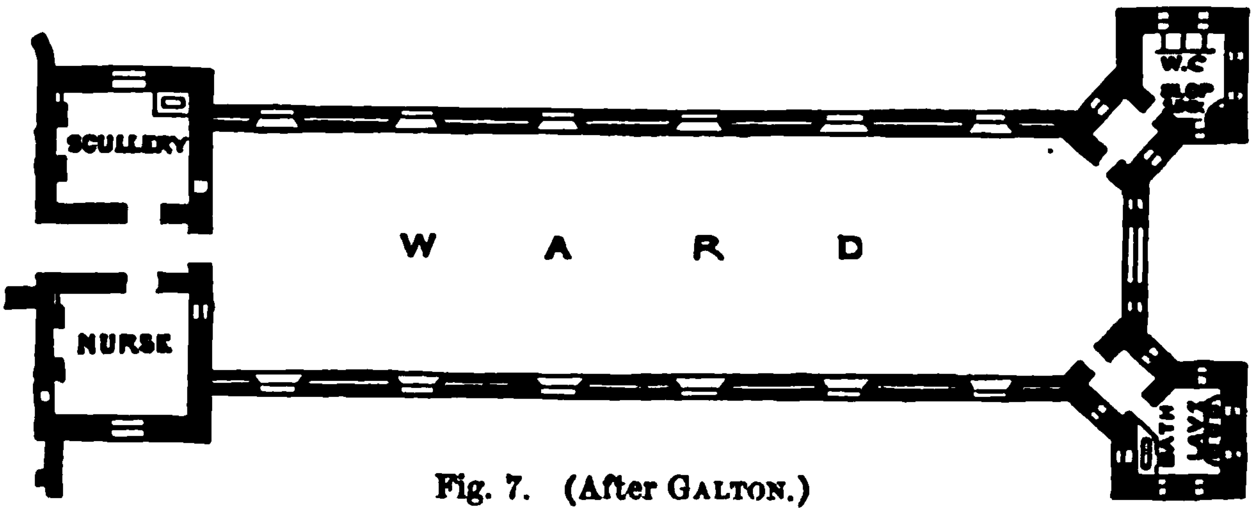

Fig. 7. (After Galton.)

age and sewerage perfect. All closet pipes should be ventilated and placed against outside walls. The various fittings should be of a light colour, to show dirt, and thus ensure thorough cleanliness. The walls

of closets and ablution-rooms should be lined with Parian cement, glazed tiles, or enamelled slate.

With regard to the materials of ward construction, it is now strongly recommended that floors should be made of hard wood, such as oak, laid on concrete and well jointed; that the walls should be lined with Parian cement, or well plastered, periodically cleaned, and whitewashed or painted; and that the ceilings should be plastered and whitewashed, or painted a light colour. Floors of upper wards ought to be non-conductive of sound.

A ward thus constructed and arranged is in itself a small hospital, and the aggregation of ward-units will depend on the number of patients to be accommodated.

In an average-sized hospital the administrative buildings occupy considerable space, and may be variously distributed. All of them, however, must be made entirely subservient to the requirements of the sick, and should not interfere with the ventilation of the wards. Usually the administrative buildings are as follows:—

Kitchen, provision-stores, and stores for bedding and linen. These should be central.

Apartments for house-surgeon, matron, and servants; consulting-room, waiting-room, surgery, drug-store, and operating-room; all of them more or less central.

Laundry, mortuary, *post-mortem* room, disinfecting-room. These should all be detached from the building.

The night-nurses should have well-ventilated bedrooms at a distance from the wards, with all the necessary appliances for ablution, etc.

The staircases for patients should be broad and easy,

and should be cut off from the connecting corridors by swing-doors. The corridors themselves should be as low as possible, well lighted, warmed, and ventilated

According to Captain Galton, the administrative buildings take up about half the cubic space of the whole hospital. As very good examples of the pavilion form of hospital on the small scale, he instances the Royal Hants County Hospital at Winchester, the Buckinghamshire County Hospital at Aylesbury, and the New Hospital at Swansea.

With regard to the cost of pavilion hospitals, Captain Galton is of opinion that, with care and attention

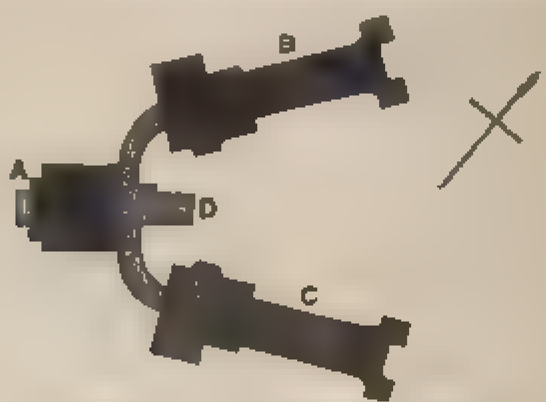

Fig 8.—GENERAL PLAN OF SWANSEA NEW HOSPITAL
A, Administration, B, Men's Wards, C, Women's Wards and Out-patients
D, Operating Room and Eye Ward. (After GALTON.)

to economy in the design, a hospital for in-patients only, and built on a favourable site, should not cost more than from £90 to £120 per bed. The Leeds Hospital, which accommodates 350 patients, cost £197 per bed; the Royal Hants Hospital, with 108 beds, and including accommodation for out-patients, cost £229; and the Swansea Hospital, also including an outside-patient department, cost £142 per bed.

Day-wards, exercising grounds, and flower or winter gardens, are great additions to the sanitary advantages

supplied by a well-constructed hospital. In summer, all the patients who are able to move about, and, indeed, most of those who are bed-ridden, should be allowed to remain during some part of every warm day in the open air. The flat roofs of the corridors, protected by awnings, could be utilised for the bed-ridden patients of the upper wards, while the corridors themselves might be appropriated by the same class of patients belonging to the lower wards. With very little extra expense the corridors could be converted into winter gardens during the colder months of the year, and might be occupied by patients in the day time without interfering with any of the administrative arrangements.

Recurrent outbreaks of erysipelas, pyæmia, or puerperal fever in some of the older hospitals have led many to believe that wooden huts would be preferable to even well-built pavilion hospitals. Indeed, Dr. Day of Geelong, Australia, maintains that, apart from the greater facilities for ventilation which such hospital huts would afford, the wood itself has a chemical and disinfectant property which renders innocuous the offensive products of organic matter, and destroys zymotic germs. According to his experiments, certain kinds of wood, such as red or yellow deal, American pine, and white deal or spruce, possess the property of converting "atmospheric oxygen into peroxide of hydrogen," a substance remarkable for its antiseptic qualities. Whether this view is correct or not, it is worthy of note that the Leipsic hospital, which has been rebuilt within the last few years, consists of fourteen of these wooden sheds or huts, and that pyæmia following upon surgical operations is seldom or never seen, whereas formerly it used to be very common. I

cannot help thinking, however, that this changed state of things is to be attributed in far greater measure to the great improvement which has taken place in the general sanitary arrangements than to any special antiseptic properties which the wood may possess. It is quite true that pyæmia or erysipelas is very often spread by carelessness, overcrowding, or neglect of cleanliness; but from instances which have come under my own observation, I believe it is not unfrequently traceable to defects connected with the drainage which permit the influx of sewer gases into the wards.

Section II.—Cottage Hospitals.

The cottage hospital system, originated by Mr. Napper of Cranleigh, is based on the principles of providing hospital accommodation for the sick poor of rural districts, with as much of the surroundings of home as possible; of permitting equality of privilege to subscribers in recommending patients, the patients themselves paying a certain sum weekly, according to their means; and of allowing any medical man practising in the district the use of the hospital for deserving cases under his care. The model cottage hospital should not have more than six beds, and must be under the management of one medical man as director, the other medical men in the district holding office as honorary medical officers. The annual cost of the establishment is defrayed chiefly by voluntary contributions and partly by the weekly payments of the patients. These weekly payments, as already stated, are regulated by the means of the patient, and vary from 2s. 6d. when the Union has to help, to 5s. or 8s. when the patient has been

earning fair wages, or belongs to a club. All fees allowed by the Union for accidents or operations are paid to the Union medical officer, in the same way as if he had attended the patient at his own home. Every subscriber, no matter what the amount of his subscription, should have equal privileges in recommending cases, and will generally be able to state what amount the patient whom he recommends can afford to contribute weekly. Cases of accident and emergency are admitted without order, but otherwise a recommendation from a subscriber must be procured, and this should in all instances be accompanied by a certificate from one of the medical staff, to the effect that the case is one deserving and fit for admission. Only those are admitted who cannot be efficiently treated at their own homes, while cases of infectious or incurable disease are excluded.

Experience has proved that in rural districts a cottage hospital of six beds will suffice for a population of 6000. The initial outlay will of course depend on whether a cottage which has already been built can be procured, and, if so, what alterations will be necessary to convert it into a hospital. If the hospital has to be built the amount required may be estimated at £600, or about £100 per bed. In converting a cottage which has already been occupied, into a hospital, the walls should be thoroughly cleaned, scraped, and afterwards re-plastered and washed with caustic lime. Attention must also be paid to the sanitary surroundings of the building.

The cost of furnishing a cottage hospital for six beds will amount to about £100, and the necessary surgical instruments to about £50. The maintenance

per patient weekly would cost from 10s. to 15s., so that the hospital, when once started and properly furnished, will require for its support an annual income of at least £150, about £25 or £30 of which will be subscribed by patients.

Although the architectural arrangements may admit of many variations, the plan best suited for a cottage hospital of six beds should provide for a nurse's room, a three-bedded male ward, a two-bedded female ward, a single-bedded ward, which can be used as an operation room, a kitchen, which may also be used as a day-ward, a scullery, and a small mortuary. All the rooms should, if possible, be on the ground floor, so that good roof ventilation and ample cubic space may be secured. Part of the roof should overhang, so as to form a sort of verandah for the use of patients. It need scarcely be added that a tasteful arrangement of flowers and shrubs in the space immediately surrounding the hospital will add greatly to its cheerfulness.

The nursing, cooking, and cleaning, can generally be efficiently attended to by one woman. As the duties are therefore of a somewhat more arduous nature than those of a nurse in a general hospital, they cannot be discharged by lady-nurses or sisters. Indeed, it is found that a homely woman from the neighbourhood, trained at the hospital or elsewhere, gets on much better with the patients than the professed trained nurse. She should be able to read and write well, and must be steady, honest, attentive, and cleanly.

If a cesspool is used for the receptacle of excreta, it should be at a safe distance from the building, and constructed as described in the Chapter on Dwellings; but where no water is laid on, the pail or dry-earth system

is to be preferred. (See *Handy Book of Cottage Hospitals* by Dr. Swete.)

SECTION III.—HOSPITALS FOR CASES OF INFECTIOUS DISEASE.

By the 131st clause of the Public Health Act, 1875, power is given to the sanitary authorities of any town or district to provide, for the use of the inhabitants, "hospitals or temporary places for the reception of the sick;" and when such provision has been made, any Justice may order the removal to the hospital of any person suffering from a dangerous infectious disease who is without proper lodging, or lodged in a room containing more than one family, or is on board ship. Judging from my own experience, however, and that of other health officers, it is very seldom that a magistrate's order is required for the removal of a patient, inasmuch as patients and their friends are, as a rule, only too glad to avail themselves of the advantages of a hospital of the kind, when proper isolation and adequate nursing cannot be procured at their own homes.

In a Memorandum of the Privy Council printed in the Appendix to the First Report of the Local Government Board, it is recommended, as a condition of the first importance, that the accommodation for isolating cases of infectious disease shall be ready beforehand, and further, that it shall be sufficient for the treatment of different infectious diseases separately. The amount of accommodation required will of course vary for different places. As regards villages, for example, it is recommended that "each village ought to have the means of accommodating instantly, or at a few hours'

notice, say four cases of infectious disease, in at least two separate rooms, without requiring their removal to a distance. A decent four-room or six-room cottage, at the disposal of the authority, would answer the purpose. Or permanent arrangement might be made beforehand with trustworthy cottage-holders not having children, to receive and nurse, in case of need, patients requiring such accommodation. Two small adjacent villages (if under the same sanitary authority) might often be regarded as one."

If further accommodation be at any time required, neighbouring cottages should be hired, or tents or huts may be erected on adjacent ground.

Practically, however, it is found that Sanitary Authorities are generally so averse to providing any accommodation of the kind, unless under the stern pressure of an epidemic, that, in rural districts especially, the health officer may consider himself fortunate if he succeeds in obtaining a place sufficiently central to meet the requirements of a whole union, or at least the most populous parts of it. With a good ambulance, patients, if fit to be moved at all, can, I believe, be moved a distance of about six miles without risk. In very sparsely populated districts, again, hospital accommodation is not required, because sufficient isolation can be secured by adopting a system of quarantine, and supplying skilled nursing.

For towns of any importance it is further recommended that the hospital provision should consist of a permanent building containing at least four wards in two separated pairs, each pair to receive patients of both sexes suffering from one contagious disease. The building should be larger than the average necessities of

the place require, so that temporary extensions may be wanted less frequently when infectious disease has become epidemic. In case, however, such temporary extensions should be required at any time, the administrative offices ought to be made somewhat in excess of the wants of the permanent wards, and sufficient free space should be reserved around the building.

It need hardly be said that the greatest difficulty is frequently experienced in obtaining a site. Vested interests at once take alarm because the popular prejudice against living in the vicinity of such hospitals is so great that property will, for the time being, depreciate in value. The site, therefore, which may be ultimately fixed upon may not be free from objection, but it should always be such that no serious sanitary objection can be raised against it. It should be sufficiently central as regards the distribution of the population of the district, sufficiently accessible from all parts of the district, and, if possible, sufficiently isolated. There ought to be no difficulty in obtaining an abundant supply of good water, nor any difficulty in getting safely rid of the excremental matters and slops. If the soil is stiff and clayey, special care ought to be taken by means of drainage, a free use of concrete or asphalt, and abundant ventilation, to secure perfect dryness of the building.

The minimum floor-space recommended is 144 square feet and the minimum cubic space 2000 feet. The arrangements for ventilation, heating, removal of excreta, disinfection, and the maintenance of the strictest cleanliness, ought to be of the most approved description.

The question here arises, and it is a somewhat

difficult one to answer, What should be the ratio of beds to the population for whose wants the hospital is to be provided? Dr. Buchanan, in a very able address delivered last year to the Medical Society of London, lays down the ratio of one bed to every 1000 inhabitants, and no doubt, taking this as an average estimate, it may be considered as fairly accurate. But much will depend upon the special circumstances of the district and population. For example, a poor crowded district will require a larger amount of accommodation than a district not crowded, and whose inhabitants are on the whole well off. In the latter case, the ratio of one bed to every 2000 inhabitants, with means for temporary extension, if it should be required, might be considered sufficient.

Temporary extension of the accommodation may be provided in the summer and autumn by tents, and in the winter and spring by wooden huts. The tents recommended are, the regulation bell-tent of the War Department, 513 cubic feet space, and the regulation hospital marquee of 3000 cubic feet space. The former should not contain more than one patient, nor the latter more than three. The ground on which they are pitched should be kept dry by means of trenches around and between them; the floors should be boarded; the approaches paved or boarded; and the tents themselves should be everywhere distant from each other at least a diameter and a half. All slops and refuse matter should be carefully removed.

With regard to huts, "dryness of site is, as in the case of tents, of the first importance. Each hut should be trenched round. Its floor should be raised a foot or a foot and a half from the earth, so as to permit the

free under-passage of air; but care must be taken to prevent the lodgment of moisture or impurities beneath the floor. A distance not less than three times the height of a hut should intervene between any two huts, and each hut should be so placed as not to interfere with free circulation of air round other huts. In huts, as in permanent buildings, for the treatment of infectious diseases, not less than 2000 feet cubic space, with 144 square feet of floor, should be given to each patient. The ventilation of huts, also, is of equal importance with that of permanent hospital buildings. It is best secured by the combination of side-windows with roof-opening, the latter protected from rain, and running the whole length of the ridge of the roof. The windows, capable of being open top and bottom, should not be fewer than one to each pair of beds, or in large huts one to each bed, nor should be of less size than the sash-window in common use for houses. The ventilating opening beneath the ridge may have flaps, movable from within the tent by ropes and pulleys, so that the opening to windward can be closed, if necessary, in high winds. Double-walled wood huts may have additional ventilation by the admission of air beneath this outer and inner wall, and its passage into the interior of the hut through openings with movable covers at the top of the inner lining. The roof should be covered with waterproof felt; the edges of the felt fastened down by strips of wood, not by nails. The hut should be warmed by open fire-places, fixed in brick-stove stacks placed in the centre of the floor, the flue being carried through the roof."

In places where no sewerage-system exists, the excreta may be removed by the pail or dry-earth system,

but in either case disinfectants should be used, and outside doors or flaps should be provided in the closet-blocks to permit the removal of the excreta directly from the closets and not through the wards.

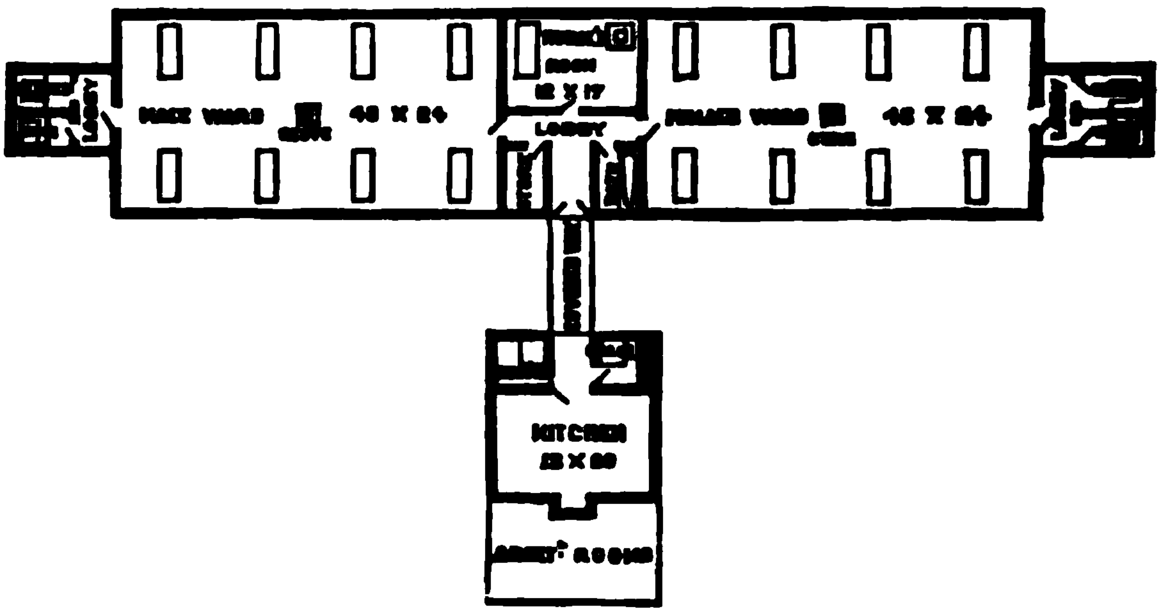

Fig. 9.

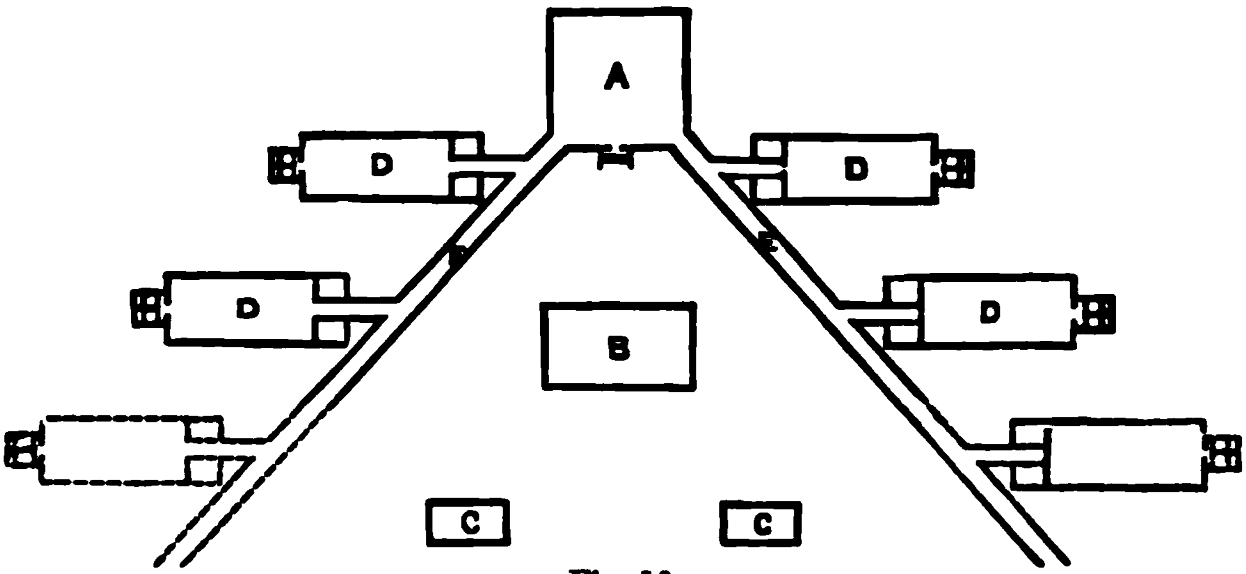

Fig. 10.

Fig. 10.—A, Administrative Buildings (Kitchen, Stores, Offices, Nurses' Bedrooms, etc.); B, Laundry, etc.; C, Disinfection, Dead-house, etc.; D, Huts for 10 patients each, with Scullery and Bath-room at end, and Closet and Sink at other end of each: E, Open Corridors. The dotted lines show direction of farther extension.)

The above are ground-plans of a hospital hut for eight patients of each sex, having the same infectious disease (Fig. 9), and of an extension of hut hospitals where plenty of ground is available (Fig. 10). Both

plans are copied from the Memorandum of the Medical Department of the Local Government Board already referred to.

Fig. 11 is the ground-plan of a hospital which is at present being built in the Solihull Union, which forms part of the Mid-Warwickshire sanitary district. The general principles of the plan are those laid down in the Local Government Board Memorandum, although

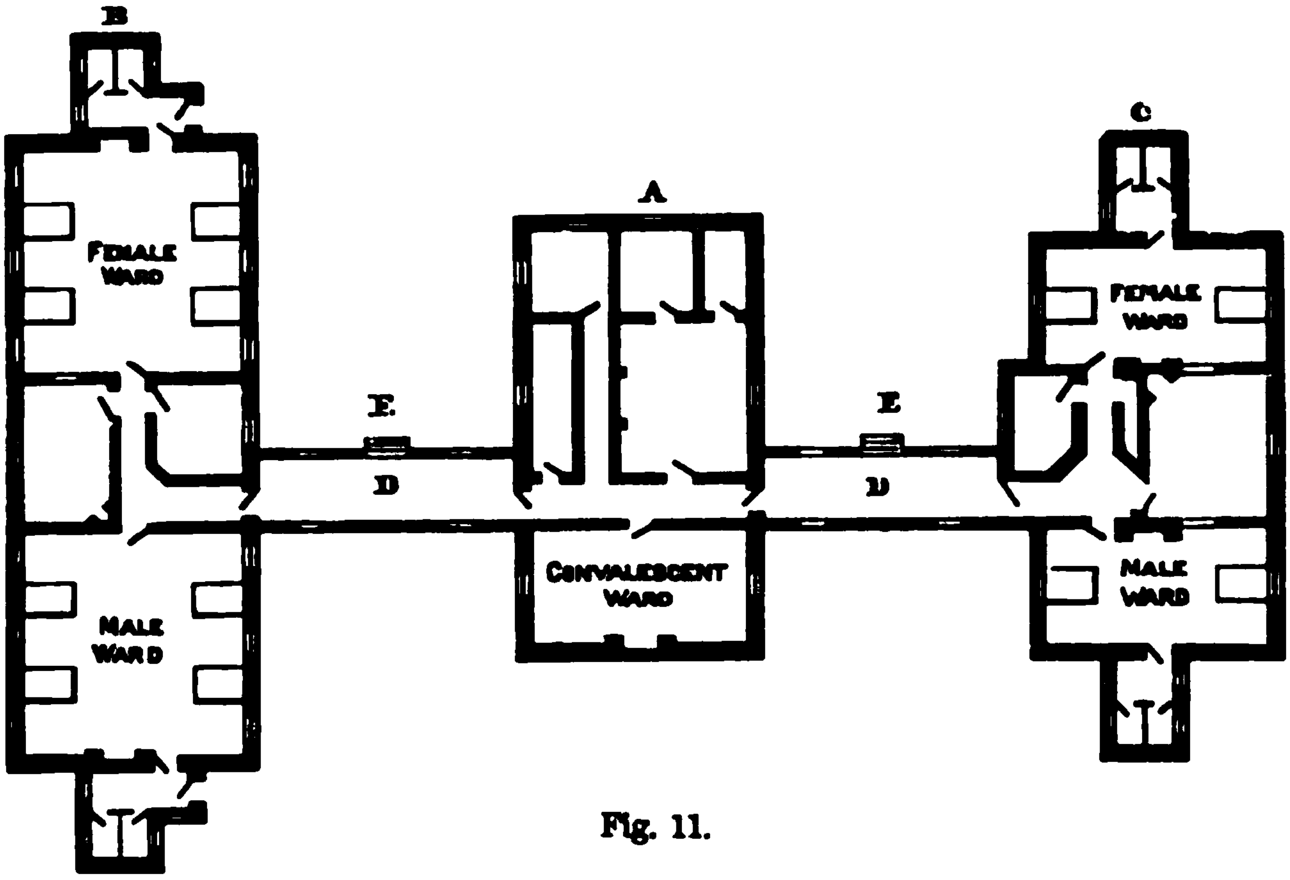

Fig. 11.

the details have been modified to suit local circumstances. The central block A contains a convalescent room, kitchen, larder, small surgery, etc. There is a doorway E in each corridor D, so that the patients in the blocks B and C can be kept completely apart if required. In addition to these blocks there are out-buildings containing a porter's lodge, a disinfecting chamber, a dead-house, a wash-house and laundry, and a shed for an ambulance. The population of the Union is about 16,000; the site covers two acres of

ground and cost £400; and the estimate of the whole of the buildings is £2000.

The following very interesting particulars which have been collected by Dr. Bland, medical officer of health for Macclesfield, with the view of aiding the sanitary authority of that town in considering the question of hospital accommodation, may be fitly quoted here. They are extracted from *Public Health*, Aug. 4, 1876:—"In Rugby they had an institution with 32 beds; the cost of building was £2069; the furnishing £380; and the average cost per bed per year, £76 : 10 : 7½. At Glasgow there were three hospitals, two of which had been in use some time, and one was in course of erection. In one of the hospitals the cost was £60 per bed, and in the other £50. At Leek the figure was very low, but that was perhaps accounted for by the fact that the structure was of wood, and it was not likely that there would be such a one at Macclesfield. There they had 14 beds, the building cost £404, and the average cost per bed was £18 : 17s.; Darlington—population 35,000, 44 beds, cost of building £10,622; cost per bed, £241 : 8 : 4; that was an immense sum. Tunbridge Wells—population 19,000, cost of building £400, cost per bed £61 : 17 : 6; Nottingham—population 92,000, 80 beds, cost of building £2931, furnishing £708, cost per bed £40 : 9 : 9; Everton (Liverpool)—population 493,000, cost of building £13,717, cost per bed £139; Bradford—population 168,000, cost of building, including furniture £22,000, cost per bed £34 : 9 : 4; Sunderland—population 100,000, 40 beds, cost of building £2000, cost per bed £30; Hastings—population 30,000, cost of building £1000,

furnishing £300, cost per bed £92 : 17s.; Coventry—population 37,617, 16 beds, cost of building £550, furniture £100, average cost per bed £40 : 12 : 6; that was an iron building. Bristol—population 195,000, cost of building £1000, furniture £200, 40 beds, cost per bed £30, four nurses; here, however, the hospital had been built on corporation land, so that the site had not been paid for."

With regard to the Rugby Hospital, I may remark that the large number of beds was recommended because the hospital was built after a violent outbreak of small-pox had taken place; while the excessive cost was caused by the fact that other works had to be stopped to obtain a full complement of men to hurry on the erection of the building, that all the time the weather was very wet and stormy, and that the men had to work during the night as well as during the day. The building was erected in a fortnight, and though the proportion of beds was as 1 to about 300 inhabitants, every bed was occupied within a few days. No difficulty was experienced in inducing every patient, no matter what his circumstances in life, to enter the hospital if fit to be removed. As a consequence the epidemic was immediately checked and kept under control, and in a comparatively short time was stamped out altogether. The Local Board defrayed all cost of maintenance, not only because it had the power to do so, but because it acted on the principle that the isolation of a patient in a hospital in reality confers more good upon the public than in most cases it does upon the patient. On the other hand, the experience of the Rugby Board also demonstrates the fact very clearly that it is a wise economy

to be prepared beforehand. If the building of the hospital had not been delayed until the epidemic broke out, a quarter of the number of beds would have sufficed, and the cost would have been proportionately less.

As an apposite illustration of the value of this ready-made provision for infectious cases, I may quote Dr. Buchanan's remarks concerning the small-pox hospital in Cheltenham, from the address already referred to:—"Here fourteen beds are permanently provided for small-pox cases in an admirable little hospital that is devised to suit the wants of well-to-do people, as well as those who may be sent to it by the public authorities. In six months of last year small-pox was brought into Cheltenham no less than six times, from Gloucester, from Birmingham, from Liverpool, and elsewhere. Seven persons ill of the imported disease were taken without delay to the Delaney Hospital, and except one individual, who was also removed to the hospital, nobody in the town caught the disease from these centres of contagion. There was literally no other small-pox in the town. How much there would have been if, in the absence of the hospital, the seven importations had been allowed to spread their contagion in a widening circle round each, can of course only be a matter of surmise."

The management of a small infectious hospital would be very much like that already described as suitable for a cottage hospital. A medical officer should be appointed who would have full powers as superintendent, but any patient should have the option of being placed under the care of his own medical attendant should he desire it. A skilled nurse can always be

obtained on the shortest notice from any of the excellent nursing institutions advertised in the Lancet and elsewhere. At times, when the hospital is not occupied, the building and bedding should be kept clean and well aired.

An indispensable adjunct to a hospital is a well-constructed ambulance. In the Appendix will be found the official instructions with regard to ambulances generally, but a few hints introduced here may likewise prove serviceable. A one-horse omnibus with door behind and easy springs can be converted into a very comfortable ambulance by taking out all the lining and polishing or varnishing the wood work. The space beneath the driver's feet should be utilised to extending the internal space, and this should receive the foot-end of the stretcher. The stretcher should be made of wire or wicker-work, and the handles should be jointed, so that when the stretcher is placed in the ambulance the handles will not encumber any of the space. Instead of a stretcher, a net hammock slung on hooks will be found to be a very comfortable mode of conveying children and young persons; indeed, for that matter, there ought to be no difficulty in slinging the stretcher itself by means of strong indiarubber bands attached to properly fixed hooks or bars. Such an arrangement would remove much of the discomfort arising from jolting which good springs do not always prevent, and it would cost little either in ingenuity or as regards expense to carry it out. In addition to the stretcher or hammock, there should be a hinged seat near the door for the attendant, and one or two hot water cans to secure sufficient warmth in cold weather and during a long drive. After being used, the ambu-

lance should be thoroughly disinfected by being washed with a strong solution of terebene, chloralum, or any other disinfectant which does not leave a disagreeable smell afterwards. The comfort of the patient would be greatly increased if, in addition to good springs, the ambulance were provided with noiseless wheels having indiarubber tires. Particulars with regard to a disinfecting chamber will be given in Chap. XIV.

When an infectious hospital is required at very short notice it may be run up of wood or corrugated iron; or, to meet sudden emergencies, it has been suggested that "flying hospitals," consisting of two or more large vans, which could be moved by road or rail, would be found to be of immense service, and they could no doubt be so arranged as to be made quite as comfortable as hut hospitals.

At seaport towns it is proposed to use hospital-ships of the "Dreadnought" type, but any hull of an old vessel, capable of floating and large enough, would suffice. Wooden huts erected on the upper deck would supply the ward accommodation, while the body of the vessel could be utilised for the administrative department. Such hospital-ships would prove of immense value in the event of cholera again visiting this country.

CHAPTER XI.

REMOVAL OF SEWAGE.

THE term sewage may be conveniently used as indicating the excrementitious matter thrown off by the bowels and kidneys, and, indirectly, the refuse, whether solid or liquid, which is constantly accumulating in inhabited places, and requires to be constantly removed if cleanliness and health are to be maintained. A consideration of this subject will therefore have reference not only to the different methods of excretal removal, but also to scavenging.

Although in thinly populated districts it might be inferred that the disposal of the excreta and house-refuse ought to be attended with very little risk, it is found practically that, owing sometimes to nearness to the house, or at other times to being close to the well, the midden or cesspool frequently becomes the cause of severe illness, and if the contents are allowed to accumulate, is always a source of real danger. Even when a house stands widely apart from every other, the occupier cannot safely neglect the sanitary obligation which rests upon him of disposing of his house refuse, whether solid or liquid, so that there shall be no foul smells to taint the air, nor foul leakage from drains or cesspools to pollute his drinking water or render unhealthy the walls and foundations of his

dwelling. And in proportion as houses are gathered together in towns or large villages, it need hardly be said that this sanitary obligation becomes more and more important. Yet nothing is more clearly established in the numerous reports of the Medical Inspectors of the Local Government Board and in published reports of health officers from all parts of the country, than the gross and utter neglect which still prevails with regard to that continuous and systematic removal of all filth which can alone ensure even an approach to cleanliness.

In the words of Mr. Simon—"There are houses, there are groups of houses, there are whole villages, there are considerable sections of towns, there are even entire and not small towns, where general slovenliness in everything which relates to the removal of refuse matter, slovenliness which in very many cases amounts to utter bestiality of neglect, is the local habit; where within, or just outside each house, or in spaces common to many houses, lies for an indefinite time, undergoing fœtid decomposition, more or less of the putrefiable refuse which house-life, and some sorts of trade-life, produce; excrement of man and brute, and garbage of all sorts, and ponded slop-waters, sometimes lying bare on the common surface; sometimes unintentionally stored out of sight and recollection in drains or sewers which cannot carry them away; sometimes held in receptacles specially provided to favour accumulation, as privy-pits, and other cesspools for excrement and slop-water, and so-called dust-bins receiving kitchen refuse and other filth. And with this state of things, be it on large or on small scale, two chief sorts of danger to life arise; one, that volatile effluvia from

the refuse pollute the surrounding air and everything which it contains; the other, that the liquid parts of the refuse pass by soakage or leakage into the surrounding soil, to mingle there of course in whatever water the soil yields, and in certain cases thus to occasion the deadliest pollution of wells and springs. To a really immense extent, to an extent, indeed, which persons unpractised in sanitary inspection could scarcely find themselves able to imagine, dangers of these two sorts are prevailing throughout the length and breadth of this country, not only in their slighter degrees, but in degrees which are gross and scandalous, and very often, I repeat, truly bestial. And I state all this in unequivocal language, because I feel that, if the new sanitary organisation of the country is to fulfil its purpose, the administrators, local and central, must begin by fully recognising the real state of the case, and with consciousness that in many instances they will have to introduce for the first time, as into savage life, the rudiments of sanitary civilisation."

"A second point which equally with the above needs to be recognised by all who are responsible for the prevention of filth-diseases, is — that filth does not only infect where it stands, but can transmit its infective power afar by certain appropriate channels of conveyance; that, for instance, houses which have unguarded drainage-communication with cesspools or sewers may receive through such communication the same filth infections as if excrement stood rotting within their walls; and that public or private water-reservoirs or water-conduits, giving accidental admission to filth, will carry the infection of the filth whithersoever their outflow reaches. Thus it has

again and again happened that an individual house, with every apparent cleanliness and luxury, has received the contagium of enteric fever through some one unguarded drain inlet; or that numbers of such houses have simultaneously received the infection, as an epidemic, in places where the drain inlets in general have been subject to undue air-pressure from within the sewer. And thus equally on the other hand it has again and again happened that households, while themselves without sanitary reproach, have received the contagium of enteric fever through some nastiness affecting (perhaps at a considerable distance) the common water-supply of the district in which they are." (See Mr. Simon's *Reports*, New Series, No. II.)

In describing briefly the various methods of sewage-disposal, it will be convenient to discuss the subject under the following sections:—

1. The water system.
2. The privy or midden system.
3. The pail system.
4. The dry system.
5. Lieurnur's, and other continental systems.
6. Systems best suited for rural districts.
7. Disposal of slops.
8. Public scavenging.

With regard to systems other than the water-carriage system, most of the information here collated has been obtained from the valuable joint report of Dr. Buchanan and Mr. Netten Radcliffe (see Mr. Simon's twelfth *Report* to the Privy Council), and from the still more elaborate report of Mr. Netten Radcliffe, contained in No. II. of the New Series already referred to.

SECTION I.—THE WATER SYSTEM.

Where there is no unusual difficulty in dealing with the sewage at the outfall, there can be no doubt that the water carriage system of sewage removal is the one best suited for large towns. In the great majority of towns, however, this difficulty has become so very serious, or the drainage in parts is so defective, that the water system has been supplemented by other plans varying according to local requirements, but all of them intended to deal more particularly with fæcal matters. Apart from considerations of cleanliness and convenience, this system possesses the additional advantage of employing the same channels for the removal of sewage which are required for the removal of waste water, and not only so, but the waste water can in this way be utilised as a very efficient vehicle for the conveyance of the excreta. In most cases the subsoil water, surface water, and the water used for domestic purposes, are all eventually discharged by the same channels, so that the drainage and sewerage of a town usually form part of the same system.

1. *Drains and Sewers.*—In any system of drainage intended to carry off surface water and drain the subsoil, it is necessary that the drainage channels should have sufficient area and declivity to maintain the discharge of the water which they receive at all times, and at its fullest flow. This quantity will of course depend chiefly on the rainfall of the locality to be drained, and upon the amount entering the drains from other sources. Thus, in country districts, the water to be carried off may be partly derived from porous strata, which have their gathering ground beyond the boundary ridges of

the drainage-area; and in towns, the water-supply artificially brought in is added to the amount derived from the drainage of the inhabited district. Moreover, as the soil acts as a kind of reservoir, the water does not enter the drains in the open country as rapidly as it falls, indeed a considerable portion of it is evaporated or absorbed by vegetation; but in towns it runs off the roofs and paved or macadamised surfaces almost as fast as it is delivered.

Guided by these considerations, engineers have estimated that the capacity and declivity of the water-channels for country districts should be sufficient to carry off the greatest available rainfall occurring during twenty-four hours in that space of time, whereas in towns they should be capable of discharging the greatest hourly rainfall on the area, and the greatest hourly supply from other sources. The depth of the greatest hourly rainfall is estimated by different authorities at from half-an-inch to an inch.

In small towns, where the storm-water, or greatest hourly rainfall, may be passed over the surface without causing injury, the main sewers need not be constructed of a capacity to discharge it,—a plan which has been carried out at Penzance and Carlisle. In other towns again—as at Dover, Ely, Rugby, etc.—most of the storm-water is carried off by the old drain-sewers, and the sewage by separate pipe-sewers; or pipe-sewers are used exclusively for the sewage, and separate brick drains are constructed for the subsoil and storm-waters.

The advantages of the pipe-sewer system are, that the pipes, if strong and well jointed, prevent percolation; that they can be quickly laid, and require much less excavation than brick sewers; that they can be

made of various curves to suit different positions; and that, with a proper declivity, they are not liable to get fouled. Another great advantage depends on the fact that the sewage can be treated without excessive dilution, and when a pumping-station is required at the outfall, the original cost and working expenses are much lessened. On the other hand, the pipe system does not fully ensure the important hygienic condition of drying the subsoil if separate drains are not laid down, or unless subsoil pipes are conjoined with sewer pipes, as in the system devised by Messrs. Brooke and Son of Huddersfield. Drain sewers, however, as they are usually constructed, do act efficiently as subsoil drains, but at the same time, it must not be forgotten that all such sewers are more or less leaky, and are therefore a constant source of danger to any wells or water-mains which may be near them.

(1.) *Construction of Drain-Sewers.*—The main drains or sewers of a town are underground arched conduits, built of brick in cement, and should be perfectly water-tight. They are generally laid on a bed of concrete, to prevent sinking of any part of the track, and consequent fracture. The cross-section preferred for them is an egg-shaped oval, with the small end downwards, and with a width of at least 2 feet, to allow men to enter them for the purpose of cleansing and repair. They should be laid out in straight lines and true gradients from point to point, so that the current shall have a velocity of not less than 1 foot, and not more than 4½ feet, per second. At each principal change of line or gradient, arrangements should be made for inspection, flushing, and ventilation; and at all junctions or curves the declivity should be increased, to

compensate for friction. No sewers or drains should join at right angles, or directly opposite the entrance of others. Tributary sewers should deliver in the direction of the main flow, and should also have a fall into the main at least equal to the difference between their diameters.

Surface-drains or gutters communicate with the underground drains by gulley-holes, which are covered with gratings, and generally fitted with syphon-traps to prevent the escape of foul air. Branch drains, leading from the houses and from the adjoining ground, are usually made of earthenware pipes, bedded on concrete, and well jointed in hydraulic mortar or cement. They should never be less than 4 inches in diameter, and should have a declivity sufficient to ensure a velocity of flow of at least 4½ feet per second, to prevent the formation of deposits. All junctions with other drains or sewers should be curved or acute-angled, and, whenever practicable, they should be made in a vertical or transversely inclined, instead of a nearly horizontal, plane. Pipes of small size should always be joined on to pipes of larger size, as 4-inch pipes into 6, 6 into 9, and 9 into 12.

No drain should ever commence in the basement of a house, otherwise the updraught produced by the increased inside temperature will occasionally draw the air through any trap. Cellars should be drained by making the drain so as to discharge upon a trapped grating communicating with the drain outside the wall of the house, or, if this cannot be readily effected, the drain should be trapped, and well ventilated either by a special pipe or an open grating. Where houses have to be drained from back to front through the basement, the drain-pipes should be carefully jointed, bedded in concrete, and

ventilated back and front outside the walls of the house. Sink-pipes, and pipes from cisterns, lavatories, or baths, should never communicate directly with the drains, or when they do so, there should always be a trap with an opening on the other side for ventilation at each point of connection. All soil-pipes should be ventilated, and no other pipes, such as overflow-pipes from cisterns, should open into them. (See Chapter on Dwellings.)

(2.) *Ventilation of Sewers.*—In order to prevent concentration or stagnation of the gases which are largely given off by sewage, it becomes a matter of the utmost importance to provide numerous openings communicating with the sewers, to ensure free ventilation. Main sewers, with steep gradients, should have a manhole, a tumbling bay, and double ventilating arrangement, at intervals of not less than 300 yards. The tumbling bay or fall is provided to allow of a flap-valve being applied to the discharging end of the sewer, and thus compel the gases to ascend through the ventilating shaft. One or more charcoal baskets may be placed in the manhole to deodorise the sewer-air as it escapes, and before it enters the ventilating chamber, but charcoal should never be used when it can be avoided, because it impedes free ventilation. The manhole and ventilating chamber are built side by side, and together constitute the ventilating shaft.

For ordinary sewer-ventilation, the manhole without a side chamber may be utilised as a ventilating shaft, or efficient ventilation can be secured by making a sufficient number of direct openings into the crown of the sewer. Manhole covers can also be utilised as ventilators by inserting an open grating into them. In cases where the sewer runs parallel with and close to

the pavement, it is advisable to carry the ventilating shaft in a sloping direction to an open grating situated in the centre of the street. All these different methods

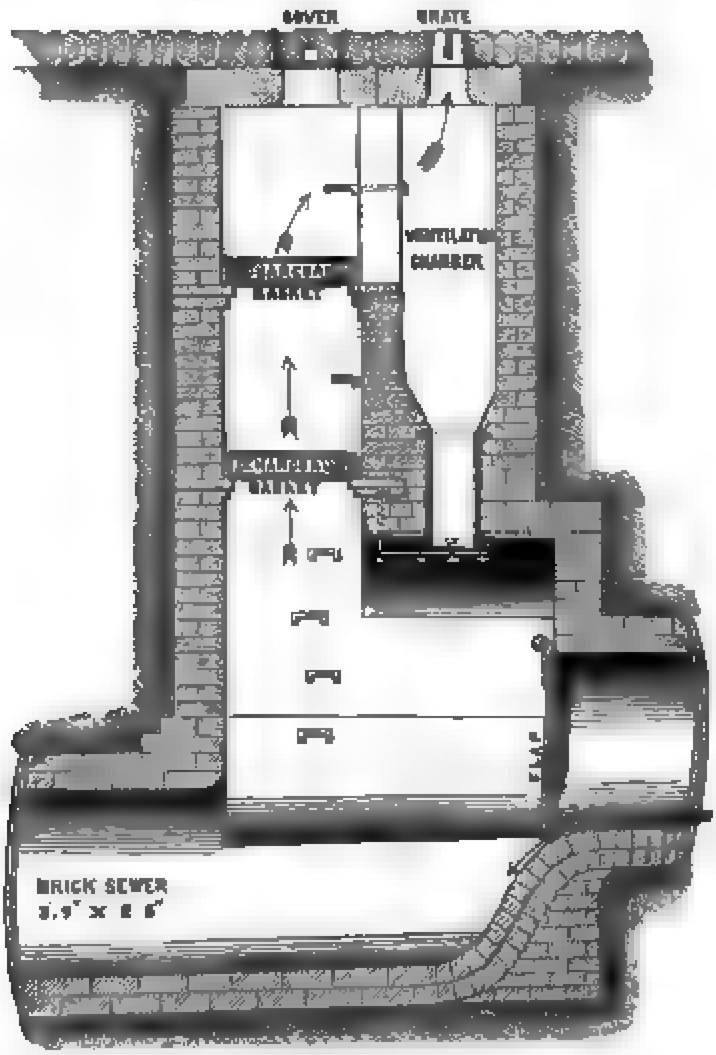

Fig. 12.—Manhole, Tumbling Bay, and Double Ventilating Arrangement. (After Rawlinson.)

of sewer-ventilation have been carried out in several places at my suggestion, and have been found to answer admirably. The mistake which is often made is to carry out extensive improvements of this description during the warm months of summer or autumn. At this period of the year the evolution of sewer-gases is greatest, and as it is evident that it must take some

considerable time to construct a large number of ventilating shafts, great complaints are made of the foul effluvia which are discharged through the openings which are first made. All such improvements, therefore, should be carried out during the colder months of the year, when the sewers are better flushed and sewer-gases are not generated so rapidly.

With regard to the number of openings, it may be said generally that the terminals of all drains and sewers should be ventilated, and the junctions of branch sewers with main sewers. According to Mr. Rawlinson there should be not less than 18 fixed openings for ventilation, or 1 at intervals not greater than 100 yards, for each mile of main sewer. Flap valves, or other contrivances, should be provided for the outlet ends of sewers, to prevent the wind from blowing in. In some cases street gulleys if left untrapped, could be utilised as ventilators. Indeed, the great object of ventilation is by means of numerous openings to so dilute the sewer-air as to render it innocuous and imperceptible to the senses. Some ventilators will act as inlets for fresh air, and others as outlets, according to the direction of the wind.

Main sewers, liable to be affected by the rise of tides or land floods, must be abundantly ventilated, in order that the sewer-air may not be forced back into the tributary sewers and drains. To provide for efficient ventilation under these circumstances, Drs. Parkes and Sanderson, in their report on the sanitary condition of Liverpool, recommended the erection of lofty shafts with a sectional area at least half as great as that of the sewers. They condemned the ventilating shafts in use at the date of the inquiry as being too

narrow, and ascertained by experiment that the Archimedean-screw ventilators, with which the shafts were supplied, only aided the extractive power by 20 per cent.

(3.) *Flushing of Sewers.*—As offensive discharges of sewer-air are generally due to the formation of deposits, careful attention to systematic flushing is highly essential. The flushing of sewers is effected by damming back the water, and removing the obstruction when a sufficient collection is made, the sudden rush clearing away any deposit that may have taken place. In addition to the arrangements for flushing, which should be provided at every manhole, there should also be a flushing chamber at the head of each sewer and drain, such chambers being flushed either from the mains where there is a public water-supply, or from water-carts. Sewers in straight lines, and even gradients from manhole to manhole, can be cleared out by using scrubbers.

No water from manufactories of an elevated temperature should be allowed to enter sewers before being cooled, because it accelerates putrefactive changes in the sewage. Blowing off steam from boilers into them is also objectionable.

With a system of sewerage properly constructed, well ventilated, and regularly flushed, the dangers arising from atmospheric pollution by sewer-gases is reduced to a minimum. Indeed, the amount of impurities in sewer-air under these conditions is so small as to be almost inappreciable to the sense of smell, and it may be laid down as a rule that whenever foul effluvia are given off it is an indication that the sewer is insufficiently ventilated, imperfectly flushed, or that it has been badly constructed in the first instance. In exceptional cases charcoal may be used, but it is wrong

in principle, as it cannot deodorise sewer-gas without impeding the ventilation. Formerly the practice of employing it in ventilating shafts was general, but all who have practical experience in the matter are now agreed that direct open ventilation is the cheapest and most effectual method, and that when properly carried out it does not give rise to nuisance. When charcoal is used, the kind best suited for the purpose is ordinary wood charcoal, broken into small pieces about the size of coffee-beans, and clean sifted. The layer in the tray or basket should never be more than 3 inches deep, otherwise the passage of the air would be almost completely obstructed. Charcoal always acts most efficiently when kept dry, but it does not altogether lose its deodorising powers when it becomes damp. Instead of baskets, Mr. Baldwin Latham introduced some time ago a system of spiral charcoal trays for the ventilation of main sewers.

But though charcoal may thus be found to be useful in abating the nuisance arising from the effluvia issuing through an exceptionally situated ventilator, it cannot be too strongly urged that the evil of a foul-smelling sewer should be dealt with at its source. If a sewer is old, leaky, or otherwise so imperfect from original faulty construction as to be nothing but an elongated cesspool, the sooner that it is abolished the better. Unfortunately, however, sewers of this description exist in almost every town, and not only so, but the gravest errors have been perpetrated in laying down house-drains in total ignorance of sound sanitary principles, and with the grossest carelessness as regards workmanship.

2. *Traps.*—That too much reliance has been placed by engineers and builders on the efficacy of traps for

the exclusion of sewer-air, is becoming every day more and more evident. Up till quite recently no adequate provision was made for drain or sewer-ventilation, and the consequence was that mechanical ingenuity became taxed to the uttermost to prevent the pent-up sewer-gases from forcing their way through the terminals of drains which for the most part were situated inside houses. When hot water is poured down a drain, or when a sewer becomes suddenly charged with a large volume of water, as after a heavy fall of rain, the forces which are brought to bear within the sewer are far greater than the resisting power of any trap, and the displaced gases make their escape often at points where they are the most dangerous. There are few traps whose resisting power exceeds that of a column of water an inch and a half in height; indeed, the greater number of them, as for example common bell-traps, have only a resisting power of about one-quarter of an inch. Besides, it should be remembered that the water in an otherwise very efficient trap will absorb sewer-gas on one side and discharge it but little changed on the other. All traps, therefore, should be regarded as at the best useful auxiliaries only, for in no case will they afford protection against the escape of foul air if proper ventilation be neglected. Some traps, such as the common bell-trap, are worse than useless, because they are readily removed, often forgotten to be replaced, and are easily broken. Many traps, too, and especially those which are supposed to protect the terminals of drains in cellars or basements, are practically useless, because the water in them speedily evaporates, and is seldom renewed.

Although there is almost an infinite variety of

traps, the most useful of them are either of what is called the mid-feather description, or are constructed on the syphon principle. Flap-traps are sometimes used for sewers or large drains, but they are merely hinged valves which permit water to flow in one direction only, and are also intended to prevent the reflux of sewer-air. In the ball-trap, a floating ball is lifted up when the water rises, and when it reaches a certain level the ball impinges on and closes an orifice.

All traps constructed on the mid-feather principle have one or more partitions dipping down into the water between the entrance and discharge pipe, and as water stands in the trap to the height of the discharge pipe, the partition is always under water. What are called D-traps are of this description, and the common bell-trap, with its various modifications, belongs to the same category. The following are illustrations of useful traps of the mid-feather variety.

Fig. 13.—Antill Trap and Lock Grate.

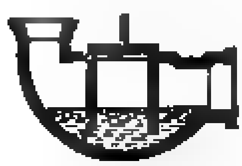

Fig. 14.—Cottam's Effluvium Trap.

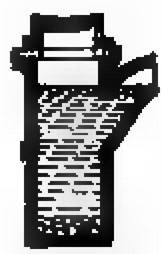

Fig. 15.—Simple Gulley Trap.

The Antill trap makes a very good sink trap, but if the sink-pipe is made to discharge on to an open grating outside, almost any article-intercepting trap will suffice. Syphon traps may be described as curved tubes, in which the whole of the curve should be always full of water. All bath and lavatory pipes should be trapped in this way, even when they do discharge on to outside gratings, to prevent the entrance

of cold air. Fig. 16 is an illustration of a syphon trap ventilated in the middle.

Fig. 16.

Amongst good ventilating traps well adapted for house drains, may be mentioned Mansergh's ventilating trap, manufactured by Jennings, Molesworth's trap, and the trap known as "The patent Edinburgh air-chambered sewer trap," manufactured by Messrs. Potts and Co. of Birmingham. Any one of these secures ventilation of the drain leading from the closet, and permits of disconnection of other pipes, in houses where considerable difficulty would be experienced in ventilating the soil-pipe. The plan proposed by Professor Reynolds of sinking a manhole to the outside drain, and of depressing the bottom of the trough so that the water shall stand half-an-inch above the outlet on the sewer side, and an inch above the mouth of the house-drain, secures the same object, and acts as a mid-feather trap, while the manhole acts as a ventilator. Mr. Banner's patent house-drain trap and patent ventilating cowl for soil-pipes, may also be mentioned as very useful and easily applied improvements. By adopting one or other of these appliances, the most serious defects connected with house-drainage may be effectually removed, provided the drains are well enough laid, in the first instance, to prevent leakage.

3. *Water-Closets.*—The situation, construction, and general arrangement of the water-closet best suited for private houses have already been described in the Chapter on Dwellings. In the crowded districts of large towns, however, the ordinary form of water-closets has proved a failure, partly on account of the complicated character of the contrivances for flushing, but chiefly

on account of the carelessness and filthy habits of the poorer classes. For these reasons some special modifications of the usual plan of closet, suited for large collections of people, and whose management may be more under the control of the public authorities, have been devised and introduced into several large towns. The arrangements which have been found to answer best are the trough-closets in use at Liverpool, the tumbler-closets in use at Leeds and Birkenhead, and what is known as the "Bristol Eject" in use at Bristol.

(1.) The *Trough-closet* may be described as consisting of a series of closets communicating with a long trough situated beneath and behind the seats which receives the excreta from each closet in the series. The lower end of the trough communicates with a drain leading to the sewer by an opening which is closed by a plug. Behind the back wall of the closet there is a small space, to which no one has access but the scavenger, and from which alone the plug can be raised by means of a handle. The scavenger visits daily, empties the trough, washes it out with a hose connected with a hydrant, and again charges it with water. As much water is let in as will cover the excreta received during twenty-four hours, and so prevent any smell. The closets are kept clean by the users, and an inspector visits occasionally to see that cleanliness is maintained. Offenders may be summoned, and fined or imprisoned.

Dr. Buchanan and Mr. Radcliffe, in the report already alluded to, make the following observations with regard to the trough-closets:—"Nothing could be more admirable than the working of the Liverpool arrangement, and nothing could be more marked than the difference between them and what are called water-closets in the

poor neighbourhoods of London and other large towns;" and this favourable opinion is fully confirmed by Mr. Radcliffe in his more recent report.

(2.) The *Tumbler-closet* resembles the trough-closet in its general plan and structure, but differs from it in regard to the arrangements for flushing. At the upper end of the tumbler-closet trough there is a swinging basin, into which water is constantly trickling, and which is so constructed, that it capsizes whenever it becomes full. In this way the contents of the trough are every now and then washed into the drain, at longer or shorter intervals as may be deemed necessary Although these closets are capable of doing good work, it appears from Mr. Radcliffe's report, and an admirable report written by Mr. Vacher, health officer for Birkenhead, that, owing to want of proper supervision and an insufficient supply of water, they have practically failed.

(3.) The *Bristol Eject.*—According to Mr. Radcliffe this consists of a strongly constructed dip-trap interposed between the privy trunk, as the receptacle is termed, and the drain. It thus admits of the ready extraction of foreign matters which may be thrown in, it is not easily broken, and as it is flushed and kept clean by the servants of the corporation, it is found to answer much better than ordinary water closets among the poorer classes of large towns.

For barracks, prisons, etc., water latrines of a much simpler construction than either of the above answer exceedingly well. An open metal trough roofed in, and with the necessary partitions and doors, receives the excreta, while its anterior upper margin constitutes the seat. In order that the excreta may be constantly

covered, the trough should be kept one-third full of water. It should also be well flushed at least twice daily, and the contents allowed to run off into a drain connected with a sewer. A plug or flap-door at the lower end of the trough will be required to prevent the water from draining off during the intervals.

There is a further advantage, common to all closets of the trough system, which may here be pointed out. In the event of an epidemic of cholera or enteric fever raging in the crowded courts where these closets are in use, it will be an easy matter to throw disinfectants into the troughs, and thus destroy the infectious power of the alvine discharges.

(4.) *Intercepting Tanks.*—This system of intercepting the solids and allowing the liquid part of the sewage to run off into the drains, has been advocated by many, on the grounds that the manure thus collected can be readily utilised, that there is no risk of clogging up the sewers, and that the sewers themselves may be constructed of much smaller dimensions. Many of the *fosses permanentes* and *fosses mobiles* on the Continent are constructed on this principle, and in this country a tank has been introduced by Mr. Chesshire of Birmingham, which has been well spoken of by Dr. Parkes, and Dr. Hewlett, health officer of Bombay. The following is the patentee's description of the tank: —"The plan or form at present preferred is that of an iron box, large enough to hold the solid part of the excreta of an average household for from eight to twelve months, and yet, when full, within the power of two strong men to lift. This box is 2 feet 4 inches long, by 18 inches wide and 18 inches deep. The pipe from the privy or closet passes into the top of

the box, by preference at the opposite corner to the outlet or waste-pipe, which, placed at the bottom of the box, is divided from the main part by a perforated grating extending across the corner and the whole height of the box. Except as to the inlet and outlet pipes, the box is hermetically sealed, though the lid can be readily removed when it is desirable to empty it. The connection of the inlet and outlet pipes to the box can also readily be separated and re-made without the assistance of the plumber."

It is doubtful, however, whether this or any other plan which merely intercepts the solids, can ever be commended for extensive use. For on the one hand, the prevention of the more solid portion of the excrement from entering the drains does not materially lighten the sewage-problem, and on the other, the detention of filth on premises, even though it be in close boxes, is wrong in principle and cannot be regarded as free from danger. Indeed, the advantage above all others which attaches to the water-closet system when efficiently carried out, is the continuous and complete removal of all excremental matters from dwellings.

(5.) *Urinals.*—These should be lined with glazed stoneware tiles, or enamelled slabs of smooth slate. They can be kept perfectly clean and inodorous by allowing a small quantity of water to trickle down them constantly.

Section II.—The Privy or Midden System.

From what has already been said it is obvious that the privy or midden system of old type, with leaky and

fœtid cesspits behind, is totally inapplicable to populous places. Cesspools and large deep ashpits in connection with privies are equally objectionable, no matter what precautions be taken. To improve the system so as to render it even tolerable, it is essential that the pit should be small in order to secure frequent removal of the contents; that it should be shallow and perfectly water-tight to prevent leakage; that it should be roofed in, to keep out rain; that it should be well ventilated; that it should be easy of access; that it should be at a safe distance from the house; and that the contents should be kept dry and inoffensive by means of sifted ashes or other dry refuse. It is not necessary that it should be drained, for if the ashes do not keep the excreta dry the system is a failure. According to Mr. Netten Radcliffe, the only kinds of midden-privies which were found to answer all these requirements fairly well are the improved middensteads of Hull and Glasgow. The *Hull middenstead* consists solely of the space under the closet seat, and its floor is formed by a flag which slopes downwards to the back wall at the ground-level there. The ashes are thrown in through the hole in the seat, and the front board of the seat is movable, to enable the scavenger to get at the contents, which are removed weekly. Privies of this description can be built for about £3. The *Glasgow middenstead* is proportionately of smaller size than the Hull middenstead, but is extended sufficiently far back from the seat to admit of the ashes being thrown upon the excrement from behind. As several families use one privy, the contents are cleared away every two days.

Other schemes, intended to diminish the offensiveness of large middensteads, as observed in Manchester,

Salford, Nottingham, and elsewhere, were all found to to have practically failed. In Manchester, where many of them were drained into the sewers, it was discovered that the sewers were becoming gradually choked up with sediment.

Section III.—The Pail System.

The more common varieties of this system are the following:—

1. Pails used without preparation (Glasgow).
2. Pails supplied with a deodorant and antiseptic (Rochdale, Birmingham, Nottingham, Leeds).
3. Pails lined on the Goux system (Halifax).
4. Pails in which ashes and house-refuse as well as excrement are deposited (Edinburgh, Nottingham).
5. Pails into which coal ashes are screened above the excrement (Manchester, Salford, Cockermouth).

In order to carry out this system in the most efficient manner, two pails are required for each closet, one to receive the excreta, and the other the ashes and house-refuse. The excrement pail may be either a wooden pail or tub, as used at Rochdale, Nottingham, and Halifax; or it may be of metal, such as that used in Manchester, Leeds, and Glasgow. In either case it is requisite that it should be round, so that it can be easily cleaned, and as regards capacity and convenience for removal, its cubic contents should not exceed 10 gallons. If of wood, it should be tarred or creosoted, and if of metal, it should be made of galvanised iron. All pails should be provided with tight-fitting lids, such as those in use at Rochdale, so that they can be carted away without creating nuisance.

When one pail is removed, another, which has been thoroughly cleaned after having been emptied at the depôt, should be left in its stead.

The ash pail should be somewhat larger than the excrement pail, and may be either a rectangular box of handy dimensions, a tub, or a galvanised iron pail.

In the Goux system as carried out at Halifax, the tubs are lined with some dry absorbent material, such as chaff, straw, shoddy fluff, hay, dry ferns, or any kind of animal and vegetable matter which is useless for other purposes. The patentees direct that these materials are to be mixed in such proportions as may be most convenient, together with a small percentage of sulphate of iron or sulphate of lime. The materials are pressed close to the bottom and sides of the tub by means of a mould which is afterwards withdrawn. A separate bin must be used for the ashes and house-refuse; but urine may be emptied into the tub, and is supposed to be absorbed by the lining, the excreta remaining tolerably dry. The tub is removed once or twice a week, according to circumstances.

When these closets are well managed they are clean and inoffensive, and the system generally has been favourably reported on by Mr. Haviland of Northampton, and Mr. Syson of Huntingdon, as well as by Mr. Netten Radcliffe. On the other hand, it has been asserted that the material used for packing generates swarms of minute flies, and that in other respects the system as it is usually carried out is not free from nuisance. Although there is perhaps too much importance attached to the absorbent power of the packing material, there can be no doubt that the advantages of the Goux system, when compared with

the midden system, cannot well be over-rated. When properly managed there is less offensiveness than with the ordinary pail system, while the resulting manure is much more easily dealt with, and, it is said, commands a readier sale than ordinary pail closet manure mixed with ashes. According to Mr. Haviland, who has specially reported on the system, filth diseases have greatly declined in Halifax since its first introduction, but this, of course, is a result which should follow the substitution of any pail system for the old-fashioned privy or midden system.

At Rochdale the contents of the ash tubs are screened by machinery at the manure depôt, the fine ashes are spread out in deep layers, and into trenches made in these layers the contents of the excrement pails are poured as received. The excrement is then covered with fine ashes, and sulphuric acid is added in the proportion of 25 lbs to 1 ton of the excrement, to facilitate drying. The proportion of excrement to fine ash in the finished manure is 80 parts of the former to 35 of the latter. After the excrement pails have been emptied they are thoroughly cleansed by water delivered from a hose at 40 lbs. pressure, and before being sent out of the yard each tub receives a small quantity of disinfectant, consisting of equal parts of chloride of lime and crude alum mixed in ten parts of water.

The net cost of the system during 1873 was £19 per 1000 inhabitants, whereas the average net cost of removing and disposing of night soil on the midden system in Rochdale and other large towns similarly circumstanced amounted in 1872 to £57 per 1000.

In Manchester and Salford a dry ash system of excrement-disposal has been combined with a pail

system. In both places Morrell's patent self-acting cinder-sifting ash-closets are being extensively introduced, and appear to answer very well.

As to the kind of closet best suited for the pail system, it is found that a closet somewhat after the improved Hull or Glasgow pattern, but with level floor and with space enough to contain the ash-pail as well as the excrement pail, is the cheapest and most convenient. According to Mr. Netten Radcliffe, "it would be difficult to suggest any great improvement upon the patterns adopted in Rochdale, Manchester, and Halifax. The compactness of the plan and the facility with which the pail closet can be adapted to the varied requirements of old towns in the reconstruction of midden-closets, is most instructively shown in the plans given of adaptations in Halifax."

As regards general results, he further states that "the pail system not only effectually does away with midden nuisance, but, as carried out in Rochdale and Manchester, it is the only one which, while utilising profitably all solid domestic refuse, appears to give promise of paying ultimately for the expense of its working."

SECTION IV.—THE DRY SYSTEM.

The difference between what is called the dry system of excretal removal and the pail system depends upon the deodorising and destroying power of the dried earth or other material, which, if used in sufficient quantity, converts the mixture into a uniform and inoffensive mass.

1. *Moule's Earth-closet.*—This consists of a wooden box with a receptacle or pail beneath, a reservoir for

the dry earth above, and an apparatus for measuring and delivering the requisite quantity of earth whenever the closet is used. The closet is made self-acting by means of a spring in connection with the seat, or it is worked by a handle as in the ordinary water-closet. It is essential that the earth be previously dried and sifted, that a sufficient quantity be thrown into the pail before the closet is used, and that the same amount be delivered over each particular stool. The quantity requisite for the deodorisation of each stool (inclusive of the urine) is found to be $1\frac{1}{2}$ lb. The slops and the rest of the urine must be removed in some other way.

This system has been introduced, with more or less success, into several public establishments in this country (Broadmoor Lunatic Asylum, the Manx Lunatic Asylum, Isle of Man, the Reading Workhouse, etc.), at the Wimbledon Camp, and several villages throughout the country. Its use in India has been very highly spoken of by Dr. Mouatt, late Inspector of Indian Gaols.

Dr. Buchanan, in Mr. Simon's Report for 1869, makes the following summary with regard to the working of the earth system:—

"(1.) The earth-closet, intelligently managed, furnishes a means of disposing of excrement without nuisance and apparently without detriment to health.

"(2.) In communities the earth-closet system requires to be managed by the authority of the place, and will pay at least the expenses of its management.

"(3.) In the poorer classes of houses, where supervision of any closet arrangements is indispensable, the adoption of the earth system offers special advantages.

"(4.) The earth system of excrement-removal does not supersede the necessity for an independent means of removing slops, rain-water, and soil-water.

"(5.) The limits of application of the earth system in the future cannot be stated. In existing towns, favourably arranged for access to the closets, the system might be at once applied to populations of 10,000 persons.

"(6.) As compared with the water-closet, the earth system has these advantages:—It is cheaper in the original cost, it requires less repair, it is not injured by frost, it is not damaged by improper substances driven down it, and it very greatly reduces the quantity of water required by each household."

The agricultural value of the earth excrement, its facility of transport, and variety of application, are also pointed out.

The disadvantages of the system are—the difficulties of procuring, drying, and storing the earth, particularly in crowded localities; the special service and attention which the closets require; the frequent discomfort attending their use when the earth is very dry and powdery; and the inadequacy of the system as a means of removing the whole excreta and slops. "Add to these circumstances the enormous aggravation of all the difficulties of the plan, when not 50 but 50,000 households have to be provided with the necessary appliances, and induced to work them properly, and we can have no hesitation in pronouncing the dry earth system, however suitable for institutions, villages, and camps, where personal or official regulations can be enforced, entirely unfitted to the circumstances of large towns." (*First Report of the Rivers Pollution Commissioners*, 1868.)

When the closets are properly managed, it appears that the fæcal matters are disintegrated, so that after a time no excrement whatever can be detected in the mixture. After keeping and drying, therefore, it may be used several times without losing its deodorising and absorbing properties, but much depends on the quality of the earth used at the outset. The suitability of various soils are given in the following order:—1 rich garden mould; 2, peaty soils; 3, black cotton soils; 4, clays; 5, stiff clayey loams; 6, red ferruginous loams; 7, sandy loams; 8, sands.

For isolated buildings and small country villages, where there is no difficulty in obtaining suitable earth, and afterwards disposing of it, and where the necessary labour and management can be procured, the system is almost perfect.

The closets may either be used as fixtures or as movable commodes, the latter being intended for use in bedrooms, hospital-wards, etc.

2. Various other modifications of the dry system have been tried or proposed, among which may be mentioned the Carbon Disinfecting and Deodorising Closet of Messrs. Weare and Co., in use in several parts of Liverpool; the charcoal manufactured from street sweepings by the Universal Charcoal and Sewage Company, Limited, at Salford; and the charcoal manufactured from sea-weed by the Carbon Fertiliser Company of Glasgow. With regard to the last, Mr. Netten Radcliffe observes that " the examination of the charcoal closets in Glasgow and the vicinity proves, as was to be anticipated, that charcoal properly applied acts as a most effective deodoriser of excrement, and that this action, in receptacles kept dry, persists for an indefinite

period. The assumption, however, that the mixed excrement and charcoal may therefore be safely stored for many months in the vicinity of or within the precincts of dwellings, appears to me to be at least premature."

Another closet which works well and which has been highly spoken of by Dr. Carpenter, Professor Corfield, and Lieut.-Col. Hope, V.C., is the closet known as the Moser Dry Closet. It is simple, automatic, and certain in its action, and is so constructed that any kind of available absorbent material can be used, such as dry earth, road dust, powdered charcoal, saw-dust, etc., and either with or without the addition of chemical disinfectants.

Although other appliances might be enumerated in connection with the dry system, it will be sufficient to point out that without proper care and supervision this system possesses no special advantages over the ordinary pail system.

SECTION V.—LIEURNUR'S AND OTHER CONTINENTAL SYSTEMS.

These need only require brief mention. Captain Lieurnur's system may be described as consisting of air-tight iron tanks situated under the streets, which are connected by iron pipes with the closets in the houses. By means of a powerful air-pump worked by steam the sewage is sucked along the pipes to these central tanks, and is afterwards converted into *poudrette*. Only a little water is used in the closets. The system has been tried in Amsterdam, Leyden, and elsewhere, but owing in great measure to its original cost, it has not met with much acceptance. Moreover it appears to be

radically defective in principle, because it is evident that the pipes must become clogged up sooner or later with fæcal matter, and indeed this result is not at all unusual. According to the Seventh Report of the State Board of Health of Massachusetts there is great complaint of the bad odour from the closets when they are situated inside houses, and in order to obviate this nuisance, the people are in the habit of flushing them with large quantities of water. The consequence is that the sewage becomes so much diluted that it could only be converted into *poudrette* at a most ruinous cost.

The *fosses permanentes* of Paris, Brussels, and other continental towns, are huge pits, placed generally under courtyards. They are lined with cement, so as to render them impervious, and are usually ventilated by shafts rising some feet above the roofs of the houses. The contents are removed three or four times during the course of the year by air-tight carts (*tonneaux*), from which the air is exhausted previous to filling, so that the sewage is forced into them through a hose by atmospheric pressure. The closets in connection with the cesspools are almost invariably in a filthy state, from the habit of standing on the seat, which appears to be prevalent in private houses as well as in public places.

The system known as *fosses mobiles* is now adopted in many continental towns, and is a great improvement on the system of *fosses permanentes.* The *fosse mobile* is a closed tub placed on a stand with wheels, and connected by a descent-pipe with the different closets or *faïences* of a house. When filled it is replaced by another of the same construction. The *abfuhrtonnen* of the Germans are of a similar description,

but in many of the larger towns the bucket or pail under the privy seat is used (Berlin, Leipsic, etc.)

Section VI.—Systems best suited for Rural Districts.

In villages where the scavenging is undertaken by the Sanitary Authority, it is just as essential that some uniform scheme of excrement-disposal should be adopted as in towns, but in the great majority of country villages provided with sufficient garden space, public scavenging is not necessary, because the solid refuse can generally be safely disposed of on the premises. The kind of alterations, therefore, which may be required to remove privy nuisance, will depend very much upon existing arrangements. If, for example, the privy abuts against the house, or is not very far from a well, it should either be removed altogether, or be converted into an earth or ash closet, and be provided with a box or pail to receive the excreta. "Inside a house," as I have said elsewhere, "the only kind of closet which can be used without risk to health must be a water closet communicating with a drain or cesspool, or a dry closet of an approved pattern; but in either case the closet must be detached from any living or sleeping room, and be properly ventilated. In country villages, however, the closet accommodation, except in a few of the better class houses, is situated outside, and is of every conceivable description. In the older villages it is sometimes represented by a rough wooden erection, with a hole dug in the ground to receive the excreta, or more frequently by a sentry-box-looking structure

stuck somewhat near the far end of the garden, and with a stinking leaky cesspit behind. In more modern villages, however, the privy and ashpit or midden-stead are found combined; but as a rule the ashpit is large and deep, leaky, and uncovered, so that at all times it is more or less of a nuisance. Then, again, in the few best class houses provided with water-closets, it is generally found that the soil-pipe is not ventilated, and that the closet discharges either into a covered cesspool, from which any gases generated can escape only into the house, or into a village-drain which was not constructed to receive excremental filth. Such, briefly, are some of the more common varieties of closet-accommodation to be met with in country villages, and I need hardly say that the structural defects connected with them are very often a source of nuisance and risk to health. How, then, are these defects to be remedied, legally, in the first place, and with a due regard at all times to efficiency and cost? Take, for example, the primitive wooden structure, with the hole dug in the ground to receive the excreta. As a rule, this kind of privy-accommodation is only met with when the cottage itself is old and dilapidated, so that it would be a sheer waste of money to insist on the erection of a new and substantial structure. All that the law demands is to fairly satisfy the requirements of health and decency, and this can be accomplished in the great majority of instances at a very trifling outlay. Let the hole be cleaned out and filled in with fresh gravel or clay, and such other alterations made that a galvanised iron pail or box can be readily inserted beneath the seat to receive the excreta. This, of course, should be regularly emptied

into the garden; and to obviate nuisance, dry earth or sifted ashes should be thrown into the pail at least once a day, and in sufficient quantity to keep the excreta covered. If the seat is hinged, there will be no difficulty in removing the pail or in throwing the ashes into it without dirtying the seat. Or take the old-fashioned privy, with its fetid cesspit behind. This can be readily converted into an inoffensive privy and ashpit combined, by filling up the cesspit to the level of the ground; paving or cementing the filled area, walling it in, and covering it as an ashpit; raising the floor of the privy a step, and with it the seat; and placing a flag sloping backwards beneath the seat, so that the excreta may be readily covered with the sifted ashes or dry refuse thrown into the ashpit. Or the ashpit may be dispensed with, and, after filling up the cesspit, the privy may be readily converted into a pail-closet. To sift the ashes, either a common riddle may be used, or such cinder-sifters as those devised by Dr. Bond, of Gloucester, and Mr. Fox, of Cockermouth. But whatever alterations may be adopted in addition to those required for privacy and ventilation, the great desideratum is to keep the excreta dry, and prevent undue accumulation. Large, deep, and uncovered midden-steads, or ashpits connected with privies, are always a source of nuisance. When they are nearly empty, the surrounding soil drains into them in wet weather, so that for the time being they become open offensive cesspools, and when full they permit of soakage into the surrounding soil. Every ashpit, therefore, connected with a privy should be little, if at all below the level of the ground; it should be cemented, or made otherwise water-tight,

and should be covered (a sloping tarred wooden covering hooked on to the back of the privy will do), to keep out the rain. Moreover, it should be of limited capacity, to prevent undue accumulation, and thereby necessitate frequent removal of the contents. Sometimes, in order to keep the contents more or less dry, the ashpit is drained, but apart from the liability to chokage of the drain, and the nuisance arising from the admission of liquid excremental filth, drainage of the ashpit should be prohibited, because, if the ashes do not keep the excreta dry and inoffensive, the system is a failure.

From these few remarks it will be observed that I advocate every possible latitude as regards the way in which nuisances connected with privy accommodation may be removed. In villages, however, for which public scavenging is considered necessary, there is no doubt that some uniformity in the nature of the alterations must be carried out, and I am of opinion that one or other of the pail systems would answer best; as, for example, the Goux system. In rural districts, provided with urban powers, the kind of privy-accommodation supplied for new houses should be carefully considered and enforced; and in one of my own districts I may mention that the closet known as Moser's closet is the one approved by the sanitary authority, although I need hardly say there are many other patents which would answer equally well. Indeed, for new houses, any patent of the kind is much cheaper than the old-fashioned privy with its huge deep ash-pit, and, what is more, it is a sure preventive against any serious nuisance. But for old-fashioned country villages, where alterations of a limited kind have to be carried

out, I do not think that any of the excellent patents to which I have referred are suitable, partly because they are somewhat expensive, and partly, too, because I find that from neglect they do not afford any advantages over the ordinary pail-system. In short, there is no dearth either of adequate appliances or material ready at hand to answer all reasonable sanitary requirements, if we could only get people to make proper use of them. (See the author's pamphlet on *Sanitary Defects in Rural Districts, and how to remedy them.*)

Section VII.—Disposal of Slops.

The term slop-water, as commonly understood, is used to indicate ordinary household liquid refuse exclusive of fæcal matter. For the most part it consists of urine, soap-suds, and the foul-washings from premises generally; and though it may not be considered as offensive as town-sewage, it frequently gives rise to serious nuisance when it is allowed to fester in rubble drains or stagnant ditches, and is a constant cause of well-pollution in country districts. In all sewered towns, the slops are of course removed by the ordinary drains and sewers, and even in most villages it is found that their disposal is in great measure a question of village-drainage in the first instance. But unfortunately, this village-drainage is so radically defective in the great majority of instances, that pollution of air and water are alike common. The shallow road drains which were intended, when first laid down, to carry off the surface water, and which, for the most part, are generally constructed of common drain pipes, or loosely laid bricks or stones, have been converted into common

sewers by conveying into them the badly laid and open-jointed drains leading from almost every house, or group of houses, in the village. If there be a water-course near the village, the drainage discharges into the stream by one or several outlets, as the case may be, and with what results it is needless to specify. Should it happen, however, that the village is some distance from a stream, then it is found that the slops discharge into open ditches by the road-side, or into field-ditches in the immediate neighbourhood of houses, and thereby often give rise to filthy nuisances in every direction. This description, it is true, only applies to the worst drained villages, but in almost all of them some of these defects are to be met with. Shallow, unevenly laid, and leaky drains are especially common, and as these are not only liable to pollute any wells which may be near them, but in consequence of the want of proper means of flushing, permit of filth-accumulations, which give off noxious effluvia, they are a source of constant danger.

And this description, it should be remembered, applies to villages in which water-closets do not exist at all, or are very rare, so that the whole of the nuisance may be said to depend upon the disposal of the slop-water. The question, therefore, at once arises whether in any given case a new system of drainage will be required, or the existing system improved to remove nuisance, or whether the slops cannot be satisfactorily disposed of in some other way. If common gutters, as some recommend, are to take the place of drains, it is clear that all the old defective drains must first be taken up and filled in with sound material, and that the gutters themselves should be properly channelled and kept

clean. But in the present condition of village-roads with badly laid side-paths, it is just as evident that these open gutters would be a constant source of nuisance, and hence, in compact villages, or villages of any size, the question of the disposal of slops is, as I have already said, a question of drainage, and need not be further discussed here. It is sufficient to state that all such drains ought to be well laid, well ventilated, and kept properly flushed, especially in warm weather, by means of a hand water-cart, which could be easily wheeled about by the road-man. (For further remarks, see next chapter.)

As regards scattered houses, or groups of houses which create nuisance by draining into open road-side ditches, such nuisance may be obviated by using the slops in the garden, and if there be not sufficient garden space, I know of no better mode of dealing with them than that devised by Dr. Bond, which consists in the use of a precipitating slop-tub with a filter. Where there is sufficient garden space, and the ground slopes away from the house, the most satisfactory way of treating them, is by sub-irrigation, and the use of Field's syphon flush-tank, but care must be taken that the sub-irrigation drains are laid at a safe distance from the well. Sometimes the drains lead into what is called a dumb-well; and provided there is no well for drinking water near, and the dumb-well is ventilated and regularly cleaned out, this may be regarded as a tolerably safe and ready method of dealing with the difficulty. But the multiplication of dumb-wells or cesspools in villages as in towns, is always attended with danger, and ought to be avoided as much as possible.

Section VIII.—Public Scavenging.

Except it be in small scattered communities, and, perhaps, purely agricultural villages, it may be laid down as a rule that no semblance of local cleanliness can be maintained, unless the scavenging, as well as the sewerage be undertaken by the Sanitary Authorities; for, in proportion as dwellings become aggregated, and populations increase, it becomes more and more difficult for individual householders to dispose of their refuse separately. Fortunately, in the great majority of agricultural villages there is sufficient garden space attached to the houses to permit at all events of the safe disposal of the solid refuse on the premises without creating nuisance, or for exceptional cases there need be little difficulty in arranging for its disposal on some closely adjacent land. Arrangements, for example, may generally be made with some neighbouring farmer, or, as Mr. Haviland has suggested, any exceptional difficulties which may arise from want of sufficient garden space might be overcome, if Sanitary Authorities were to provide a spare corner of ground, known as "the muck acre," to which householders could remove their solid refuse. But whenever in any village or town these difficulties are ascertained to be at all common, it then becomes the duty of the Sanitary Authority of the district to undertake the efficient scavenging of premises, either through their own officers, or by contract, and in case of refusal or neglect, they can be compelled to do so by order of the Local Government Board. In any case, however, the Sanitary Authority is virtually responsible for the cleanliness of its district, either by enforcing the provisions of the

Public Health Act for the prevention of nuisance arising from filth-accumulation on individual premises in places to which scavenging does not extend, or by systematically preventing the occurrence of nuisance in places where public scavenging has been introduced.

As regards the general details of public scavenging, much will depend upon local circumstances, and upon the method of excretal removal which may be found to prevail in any particular town. Where the old-fashioned midden system is still allowed to be carried on, the house refuse is mixed with the excreta, and both are carted away together. In the majority of towns, however, the ashes and other solid house-refuse must be collected and removed by a separate system, which necessitates the use of dust-pails or bins, and the daily or frequent visit of the scavenger's cart. For dwellings occupied by single families, the dust-box or pail answers very well, it being large enough to contain the dry refuse collected during the twenty-four hours; and as it is emptied into the scavenger's cart at a stated time daily, any accumulation about the premises is prevented. But in crowded parts, where families live in separate tenements, the whole of the ashes and dry refuse is usually, in the first instance, emptied into a common dust-bin, and afterwards carted away when the bin becomes full. In this case it is necessary that the bin should be roofed in, in order to keep the contents dry, and that it should be well ventilated. No slops or excrement should be allowed to be thrown into it, because the former excite fermentation in the vegetable and animal matters contained in the refuse, and the latter renders the contents offensive. It need scarcely be added that, in a sanitary point of

view, dust-bins should be frequently and regularly emptied.

In large towns where the pail system of excretal removal is carried out, the excrement-pails should be removed in specially covered vans, and the ashes and dry house refuse in separate carts. The following is Mr. Netten Radcliffe's description of the system of scavenging as carried on at Rochdale:—

"The town is divided into six districts for the purposes of removal, and the dry house refuse is removed at the same time as the excrement, a dust-cart accompanying each night-soil van for the purpose. The removal is all effected during the ordinary working hours of the day, the vans commencing their rounds at 7.0 a.m., and ending at 5.30 p.m. Each night-soil van makes five rounds daily. It leaves the yard laden with clean empty pails, each pail containing a quantity of a 'disinfectant,' and returns carrying the pails containing excrement, for which the empty pails have been substituted. The process of substitution is effected by the scavengers withdrawing from beneath the closet seat the pail containing excrement, covering this up with the lids already described, removing it to the van, an empty pail being left in its place, and on placing the pail in the van sprinkling over the outer lid a little carbolate of lime. The ash tub is then carried to the dust-cart and its contents simply tilted into it. Each pail closet is numbered and registered, and the scavengers proceed from closet to closet systematically, according to the portion of their district within the day's beat, revisiting at the end of each round the closets from which the pails had been removed, and those, if any, which had been omitted. The greatest

number of omissions for any one month in the whole town has been 43, or only one [illegible] Every Monday the scavengers' returns are examined, and a supplementary van is sent out to rectify omissions. In the case of tenement-houses and closets used by several families the excrement pails are removed twice or thrice weekly."

In scavenging old-fashioned middens and privies the nuisance is so intolerable that the scavengers can only make their rounds during the night-time, and even then the stench is so horrible that the air of every street or court along which the cart passes becomes for the time being positively dangerous to breathe. People who are out late at night may smell these carts a long way off, and when they do so they generally make a hasty retreat.

One very important branch of scavenging in urban districts is involved in the cleansing of streets and back courts, many of which are so badly constructed that it is next to impossible to prevent filth-accumulations. Gutters are often so irregularly laid that after rain or flushing there are small stagnant pools to be seen throughout their whole extent. The surfaces of macadamised streets again are being constantly pulverised, and give off clouds of dust containing large quantities of decomposing animal and vegetable matter in dry weather, or are covered with liquid mud when it is wet; while paved streets present numerous interstices which cannot be efficiently cleansed, not even when scrubbing-machines and flushing are both used. There is no doubt, therefore, that the new plan of street construction which has lately been introduced into some parts of London and other large towns, whether it be

wood-pavement or asphalte, and preferably the former, will not only prove to be economical in many ways, but will also be productive of great sanitary advantages. Tar-asphalte, if properly laid, is especially applicable to side-paths, back courts, and narrow streets, where the traffic is inconsiderable, because it is cheap, durable, non-absorbent, and washable.

CHAPTER XII.

PURIFICATION AND UTILISATION OF SEWAGE.

It has already been shown, in the previous chapter, that of all methods of sewage-removal, the water-carriage system is the one which best meets the requirements of large towns, when there is no great difficulty of dealing with the sewage at the outfall. It is the speediest, cleanest, and, in the long run, the most economical, method which can be employed on an extensive scale, and its general sanitary advantages are now placed beyond dispute. But no sooner had this difficult hygienic problem been solved by engineering skill, than another of even greater difficulty arose. The eagerness of early sanitary reformers to get rid of human refuse at any cost blinded them to the fact that, by pouring sewage into the nearest watercourse, they were merely removing the evil from one place to take effect somewhere else. No consideration was paid to the probable results of the method on the future water-supply of increasing populations, nor to other serious consequences which speedily began to declare themselves. Rivers were in reality converted into sewers, and the communities down stream, while they loudly complained of the annoyance and danger to health, added to the nuisance by following the general example. After a time it was discovered that the mouths of navigable

rivers were being silted up, that valuable stocks of fish were destroyed, that water-supplies were contaminated, and that riparian rights were in every sense grossly violated. Such were some of the more important evils resulting from river-pollution, and eventually legal prohibitions were issued in many places to prevent their continuance. These prohibitions have multiplied, until the sanitary authorities throughout the country are at last compelled to purify the sewage of towns before it is discharged into any watercourse at a distance from the sea, or run the risk of incurring legal penalties; while the Rivers' Pollution Act of the present year absolutely prohibits any new drainage-works which may in future be carried out from discharging into any river or stream without previous purification.

Meanwhile there has been an increasing number of economists who have rightly maintained that sewage was not only wasted, but worse than wasted, when discharged into rivers, and that, on account of its manurial value, its proper destination was the soil. Hence has risen the larger question of the utilisation of sewage, the merits of which will be best understood by considering first the composition of town-sewage.

Section I.—Town-Sewage.

In addition to excretal matters, town-sewage contains the effete products of various trades and manufactures, animal and vegetable *débris*, mineral detritus from roads and streets, and the like, all of which are held in suspension or solution by an amount of water varying according to the water-supply in the first instance, and depending, in the second place, on the

rainfall and amount of subsoil-water entering the sewers at different times of the year. This varying amount of water is one of the chief difficulties to be encountered in the utilisation of sewage, and, apart from other considerations, it has led Mr. Menzies and other eminent engineers to recommend the introduction of the pipe-sewer system, which has already been described, into all towns where sewerage-plans have yet to be carried out. The sewage, delivered from pipe-sewers, consisting almost exclusively of excretal matters, slops, and the water-supply, can of course be readily estimated in all cases, and is much more easily dealt with. But with common drain-sewers, which receive in addition the rainfall and subsoil-water, not only is the extent of dilution much greater, but it is constantly varying in amount. Thus, to quote the data given in the Third Report of the Sewage of Towns Commissioners (1865), it is considered that 60 tons per head per annum (= 36 gallons per head daily) is the average amount of normal or dry-weather sewage in the metropolis, but this amount is further increased by the rainfall and subsoil-water from two-thirds to an equal volume. With pipe-sewers, however, the amount of sewage equals the amount of water-supply, and in towns supplied on the constant system, this ought not to exceed 20 gallons per head daily, or about 33 tons per head per annum. In the face of such considerations as these, the sanitary and practical importance of Mr. F. O. Ward's famous alliterative dogma of "the rainfall to the river, and the sewage to the soil," becomes at once apparent.

But, with either system of sewers, the value of the sewage may be said to depend entirely on the excretal

matters, and the amount and relative value of these will be gathered from the following data:—

According to Mr. Lawes, the subjoined table represents, as the result of numerous analyses, the average amount and composition of excretal matter discharged by a male adult daily:—

	Fresh Excrements.	Dry Substances.	Mineral Matter.	Carbon.	Nitrogen.	Phosphates.
	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.
Fæces	4.17	1·041	0·116	0·443	0·053	0·068
Urine	46·01	1·735	0·527	0·539	0.478	0·189
Total	50·18	2·776	0·643	0·982	0·531	0·257

In a mixed population, the actual amounts per individual will obviously be considerably below this average, and, according to Dr. Parkes, they may be estimated at $2\frac{1}{2}$ oz. fæcal matter and 40 oz. urine daily, an estimate which gives 25 tons solid fæces for every thousand inhabitants annually, and 91,250 gallons of urine. But the above table also shows that the manurial value of the urine voided in the twenty-four hours greatly exceeds that of the fæces passed in the same time. Indeed, the relative value, as determined by numerous analysts, is approximately as 6 to 1.

The actual value of both urine and fæces in sewage has been estimated by Messrs. Lawes and Gilbert at 6s. 8d. per individual per annum, supposing that 10 lbs. of ammonia is a fair estimate of the amount voided in that time. When the sewage averages 24 gallons daily per individual—that is, 40 tons per head per annum—its money value, according to this estimate would be 2d. per ton, and the value per ton will decrease in proportion to the rate of dilution above this average. It

may be added that this estimate corresponds very closely with the money value of average sewage given in the First Report of the Rivers Pollution Commissioners (1868); for it is there stated that the value of the "*dissolved* constituents in 100 tons of average sewage is about 15s., while the *suspended* matters only contain about 2s. worth of them." In other words, 100 tons are worth 17s., or about 2d. per ton.

These monetary details are quoted here because they largely affect the question of utilisation of sewage, and have more or less influenced the various plans which have been proposed or carried out in this direction.

SECTION II.—SCHEMES FOR THE PURIFICATION AND UTILISATION OF SEWAGE.

These have generally been classified under the separate headings of precipitation, filtration, and irrigation processes, and the more important of them are as follows:—

1. *Precipitation processes.*—In all of these processes the main object in view is the purification of sewage by the introduction of chemical agents. The dissolved matters are precipitated to a greater or less extent, and can therefore be separated along with the suspended matters, while the effluent water is supposed to be in a sufficiently pure state to allow of its being discharged into a stream or river without producing any serious degree of pollution. It is needless to say that many of them have proved to be signal failures, chemically as well as financially. Fictitious values were given to the resulting manure, and some of the schemes which otherwise might have proved fairly successful, were

simply ruined by being made stock-exchange speculations. Indeed, it cannot be too widely known that, no matter what process may be adopted, Sanitary Authorities must be prepared to pay a subsidy for the chemical treatment of their sewage, because it is now clearly established that the manure, or whatever other products may be obtained, will in no case pay, or nearly pay, for the cost of purification. Several of the following processes have been tried and failed, while others are still on trial, and they are given here rather to show what has been attempted in this direction, than as selected instances of success or failure :—

(1.) *Precipitation by Lime.*—This process was at one time carried out on an extensive scale at Blackburn, Leicester, and Tottenham. It consists in mixing the sewage at the outfall works with a certain proportion of cream of lime, when a copious precipitate takes place, which may be sold as manure or converted into bricks. The supernatant fluid flows off in a comparatively clear though milky condition, but contains about half the putrescible matter of the sewage, and a great proportion of the fertilising constituents. The plan has been pronounced by the Rivers' Pollution Commissioners to be a conspicuous failure, "whether as regards the manufacture of valuable manure, or the purification of the offensive liquid."

At Northampton, a modification of this process, by the addition of iron perchloride and subsequent filtration through calcined iron ore, has also been tried, but with little better results. Other salts, such as salts of zinc and manganese, and carbolates of lime and magnesia, have been proposed as adjuvants to the lime-process, but they all fail in separating the ammonia and

other manuring material. They disinfect the sewage for the time being, but do not prevent subsequent decomposition.

(2.) *Blyth's process* consists in the addition of a salt of magnesia and some lime superphosphate, or superphosphate of magnesia and lime water, with the view of purifying the sewage by the formation of the triple phosphate of magnesia, ammonia, and water. Such a precipitate, however, can only take place in water containing an excess of ammonia; so that the whole process, while being more costly than others, was found to be as inefficient.

(3.) In *Holden's process*, a mixture of iron sulphate, lime, coal-dust, and clay, is added to the sewage, but it fails to remove the nitrogenous matters in solution, and indeed increases their amount by dissolving some of the suspended constituents.

(4.) *Bird's process*, which was tried at Cheltenham, but abandoned, consists in the addition of crude sulphate of alumina, and subsequent filtration through coke. The sulphate of alumina was obtained by treating pulverised clay with strong sulphuric acid. In this and Stotherd's process, which somewhat resembles it, the effluent liquid was not found to be sufficiently purified for admission into a river without creating a nuisance.

(5.) *The "A B C," or Sellar's process.*—This process, which attracted so much attention some few years ago, had a prolonged trial at Leamington on an extensive scale, and was ultimately pronounced to be a failure. It consists in adding a mixture of alum, blood, clay, charcoal, a salt of manganese, and other ingredients, to the sewage as it enters the works. A precipitate is

thus obtained, which settles to the bottom of the tanks in the form of a soft black mud. This is afterwards pumped up into receptacles, from which it runs into centrifugal drying machines, or is removed into drying chambers. But in either case it is subsequently spread out on the ground to complete the drying process, and the mass is from time to time sprinkled with sulphuric acid to fix the ammonia. It would appear, from the conclusions of the Rivers' Pollution Commissioners, that, though it is superior in some respects to the processes already described, it is nevertheless an inefficient purifier. It is but right to state, however, that more recent experiments conducted at Crossness with London sewage have yielded somewhat more satisfactory results. The experiments were conducted during the three months ending November 30, 1872, and upwards of 11 million gallons were operated on. According to the report of Mr. Keates, the analyst under whose supervision the experiments were carried on, the effluent water was clarified to such an extent as to be admissible into any ordinary river without producing a dangerous degree of pollution, nor did he find the manufacture of the manure to be productive of nuisance. But the value of the manure did not exceed 20s. per ton, and the Committee decided that, considering the cost of the manufacture, the process could not be adopted with any hope of profit to the ratepayers. The works were therefore discontinued.

(6.) *The Phosphate process,* as proposed by Messrs. Forbes and Price, consists in adding to the sewage a solution of the native phosphate of alumina, dissolved in sulphuric or hydrochloric acid, and diluted in water. The resulting manure has been estimated by Dr. Voelcker

at £7 : 7s. per ton. The effluent water is clarified and disinfected, but not by any means freed from putrescible or fertilising matters, and the originators of the process have themselves pointed out that it is only intended as a preliminary step to irrigation, where that can be carried out. Where irrigation is impossible, the process is completed by adding milk of lime, to precipitate the phosphates in solution. The process generally has been favourably reported on.

(7.) In *Hillé's process* the mixture consists of lime, tar, calcined magnesium chloride, and some other substance not named. The lime is slaked, and the tar added while it is hot. The whole ingredients are subsequently mixed with water, and flow through a large tap into the tank which receives the sewage. Here precipitation takes place, and the sewage, completely deodorised, passes into a second tank, where the deposit settles. The effluent water is afterwards filtered through a charcoal basket into a third tank, is received into a fourth, and overflows from this into a small brook. The working expenses of the process are small, but the manure is not valuable.

(8.) *General Scott's process* differs from others already described, in the introduction of the chemicals into the sewer at some considerable distance from the outfall. The precipitating agents consist of lime and clay properly pulverised, and the motion of the sewage in its onward flow ensures their thorough admixture with itself before it reaches the outfall. The resulting sludge which is formed, instead of causing any deposit in the sewer, as some anticipated, acts rather as a scouring agent, and keeps the sewer clean. When received into the outfall tanks, the sewage is found to be deodorised,

and here the suspended matters are deposited. These are subsequently removed to be dried and burnt, and are thus converted into a useful cement. The drying process, it appears, is not attended with any nuisance.

The British Association Sewage Committee have reported favourably on the whole process, as solving one of the difficulties of the sewage question, namely the separation and deodorisation of the offensive ingredients in an efficient manner, at a comparatively small cost, and of easy application on a large scale. The effluent water, according to the Committee's analysis, contains rather more than two-thirds of the chlorine and of the dissolved nitrogen of the sewage. It is therefore too valuable to be wasted, and too impure to be discharged into a river, and can only be properly dealt with by irrigation.

General Scott's process has been carried on at Ealing, West Ham, and Birmingham.

(9.) *Whitthread's process*, which has also been favourably reported on by the British Association Committee, consists in adding to the sewage a mixture containing two equivalents of dicalcic phosphate, one of monocalcic phosphate, and a little milk of lime. The resulting precipitation was found to be very rapid, and the supernatant fluid clear and inoffensive. Suspended matters were completely removed, and the organic nitrogen nearly so. It was considered by the Committee that the manure would be valuable, as it contained a large amount of lime phosphate and 3 per cent of ammonia. As the effluent fluid contained phosphoric acid and ammonia, it would be suitable for irrigation.

(10.) *Dr. Anderson's process*, first tried at Nuneaton,

has been carried on much more successfully during the last three years at Coventry. It consists in adding an impure sulphate of alumina, made by dissolving aluminous shale in sulphuric acid, to the sewer water, which is kept constantly stirred, and which afterwards flows into a series of settling tanks. The whole of the machinery is admirably planned, and the effluent, especially after it has passed through an adjoining filtering area, is very clear and fit to be discharged into any river. The resulting manure does not command a ready sale, and no doubt the works have been carried on at considerable loss, although the Company has relieved Coventry from all the penalties involved in an injunction in Chancery.

2. *Filtration processes.*

(1.) *Simple Filtration.*—In this process the sewage is merely strained or screened, so that, although almost all the suspended matters are removed, the effluent fluid is not by any means purified. The mud which collects at the bottom of the filtering tanks is generally mixed with the town ashes and sold as manure.

(2.) *Carbon*, as in Weare's process, has been tried to purify sewage by filtration, but it does not appear to have been very successful. Very possibly if it could be obtained at a cheap rate and the filtration were made intermittent, it would be found to answer with small quantities of sewage where land cannot be procured. A cheap kind of carbon is now manufactured for this purpose called *Sanitary Carbon.*

(3.) *Upward Filtration.*—This process was at one time carried on at Ealing, but the results were not satisfactory.

(4.) *Intermittent Downward Filtration.*—Amongst

the numerous important experiments conducted under the direction of the Rivers' Pollution Commissioners, there were none attended with better results than the filtration of sewage through a considerable depth of soil. The experiments were made on sand, on a mixture of sand and chalk, and on different soils. The results varied a good deal according to the quality of the soil, but in all of them it was found that the suspended matters were entirely removed, and that the organic carbon and nitrogen were greatly reduced. According to the report of the Commissioners, "These experiments also show that the process of purification is essentially one of oxidation, the organic matter being to a large extent converted into carbonic acid, water, and nitric acid; hence the necessity for the continual aëration of the filtering medium, which is secured by intermittent downward filtration, but entirely prevented by upward filtration."

The process has for some time been carried on at Merthyr Tydfil, according to the plans of Mr. Bailey Denton, C.E.; and the following abstract from the Report of the British Association Sewage Committee will afford a sufficient description of the various details and the results:—The filtering area or farm is about 20 acres in extent, and consists of a very porous gravelly subsoil, covered with vegetable mould. It has been pipe-drained to the depth of about 7 feet, the drains conveying to the lowest corner, where the effluent water is discharged into a small stream leading into the river Taff. The area is laid out in square beds, intersected by paths, along which are constructed the main carriers, which receive the sewage from the outfall sewer, where it is screened through a bed of clay, and distribute it over

the beds. In order to supply the sewage on the intermittent system, the area is divided into four equal portions, each portion receiving the whole of the sewage for six hours in succession, and thus leaving an interval of eighteen hours for rest and aëration of the soil. The surface of the land is cultivated to a depth of about 18 inches, and is laid up in ridges to allow of the sewage running down the furrows. The ridges are planted with cabbages and other vegetables.

The results of the process, as stated by the Committee, are highly satisfactory. All the suspended matters are removed, and the ammonia and nitrogenous organic matters are almost completely oxidised, so that they escape in the effluent water as nitrites and nitrates. They add, however, that though the sewage is thus efficiently purified, the process cannot be regarded as one of utilisation.

Since that report was published in 1872, additional land has been obtained to the extent of over 200 acres, in order that the intermittent downward filtration process should be supplemented by simple irrigation, and that better returns might be obtained.

The requisite extent of filtering area, as estimated by the Rivers' Pollution Commissioners, is 1 acre drained to a depth of 6 feet for every 3300 of the population, but this ratio must vary according to the nature of the soil. The soil should be porous and the surface have an easy slope.

3. *Irrigation.*—It is now generally conceded that this is the only process which fully meets all the requirements attaching to the disposal of sewage; in other words, it is the only one which, while it purifies the sewage efficiently, realises the highest profits, and may be

carried on without creating any nuisance or detriment to the health of the neighbouring inhabitants. But in order that the process may be carried out satisfactorily, it is necessary—

(1.) That the acreage be sufficient. This will depend in great measure on the looseness or porosity of the soil; —hence to lay down as a rule that 1 acre should be allowed for every 100 inhabitants, which is the estimate usually given by engineers, is manifestly illogical.

(2.) The land to be irrigated must be drained, and stiff clayey soils broken up and mixed with ashes, sand, or lime.

(3.) The surface must be irrigated on the intermittent system, to ensure sufficient aëration of the soil.

(4.) The ground should be laid out in broad ridges and furrows, the sewage being conveyed along the tops of the ridges in open carriers, and made to flow gently down the slopes by inserting temporary sluices in regular succession and at regular intervals. At Breton's Farm, near Romford, rented by Mr. Hope, the breadth of the ridge is 30 feet, giving a slope of 15 feet on either side of the carriers. At Lord Warwick's farm near Leamington, Mr. Tough, the manager, informs me that the ridge varies from 50 feet wide according to circumstances.

(5.) There must be a rotation of crops, such as rye-grass, peas, maize, different roots, cabbages, etc., and where land is plentiful it always pays to let portions of it rest for a time for the growth of cereal crops.

(6.) The sewage should be delivered in a fresh state, and freed from the coarser portion of its suspended matters. This may be effected either by precipitation, filtration, or screening. At Lord Warwick's farm, the

[redacted]

borough of Warwick farm, and the Rugby farm, the sewage is simply screened and delivered fresh on to the land.

Such, briefly, are the principal details connected with sewage-farming, and it is the neglect of one or more of them which has brought so much opprobrium on the system. If the irrigated soil becomes water-logged and swampy, the fault lies with the engineering and management, not with the system. Or, again, if the farm becomes a nuisance, it is because the sewage is not properly distributed, or the carriers kept free from deposit.

The average profit per head of population, after deducting the percentage for outlay in the preparation of the farm, and working expenses, has been estimated at from 2s. to 3s. 9d., and there is reason to believe that when the system becomes more widely known and appreciated, the money results will considerably exceed even these.

The general advantages of the system will be best given in Professor Corfield's own words, from whose work many of the facts here given have been collated. His conclusions are as follows:—

"(*a*) That by careful and well-conducted sewage-irrigation, especially with the application of moderate quantities per acre, the purification of the whole liquid refuse of a town is practically perfect, and has been ensured in cases where it was not at all the object of the agriculturist; and that it is the only process known by which that purification can be effected on a large or small scale.

"(*b*) That perfectly worthless land, blowing sea-sand for instance, can be made in this way to support large and valuable crops.

"(*c*) That the quantity per acre of all crops obtained from even the best land is enormously increased.

"(*d*) That it reduces to a great extent, or renders entirely unnecessary, the usual amount of artificial manures of all kinds, by supplying a manure especially adapted, from its complex constitution, for the nourishment of crops, supplying it, moreover, in a state of solution—that is to say, in the most readily absorbable condition, and supplying at the same time that most necessary aid to vegetation, water, which often converts what would otherwise have been a very heavy loss into a very handsome profit.

"(*e*) That by it the farmer is rendered entirely independent of drought, so that he can be practically certain of his crops, and moreover be able to transplant them as much as he pleases.

"(*f*) That, with all these advantages, it is no wonder that it has been found to pay; and when its management is more thoroughly understood, it will doubtless be found to be a valuable source of income to towns." (*Treatment and Utilisation of Sewage*, 2d edit.)

Judging, however, from more recent experiences in sewage-irrigation, it would appear that some of these conclusions of Dr. Corfield, and especially the last, admit of a certain amount of qualification. For while there can be little doubt that it will always reimburse the farmer, even when he pays a certain rental for sewage laid on to his farm, it becomes quite a different question when this rental is regarded as a valuable source of income to towns. For example, the town of Leamington, with a population of about 22,000 inhabitants, receives from the Earl of Warwick an annual

rental of £450 for the sewage, but then it costs the ratepayers about £800 a year to pump the sewage on to the farm, besides the interest on an initial outlay of about £16,000 expended on pumping-station and other works. Although no statement of accounts has been published I have reason to believe that the farm pays, but deducting the sum received for the sewage, it is clear from these figures that it costs Leamington, at the lowest estimate, about £1300 a year to get rid of its sewage, and taking all things into consideration the town may be congratulated in getting over its difficulties even at this rate. Of course, where pumping is not required, as at Rugby, the return received for the sewage is a set-off, though it be a comparatively small one, against the interest on initial outlay. It is very doubtful, therefore, whether sewage-irrigation will ever prove a valuable source of revenue to any town, no matter how favourably it may be circumstanced; and indeed, as regards most towns, it becomes like other processes of purification, a question of least cost, but with this wide difference, that it secures the best results.

The comparative results of the different processes of purification are stated by the Rivers' Pollution Commissioners as follows:—

Average Results.

	Percentage of dissolved Organic Pollution removed.		Percentage of suspended Organic Impurity removed.
	Organic Carbon.	Organic Nitrogen.	
Chemical processes .	28·4	36·6	89·8
Upward filtration . .	26·3	43·7	100·
Downward filtration .	72·8	87·6	100·
Irrigation	68·6	81·7	97·7

This table shows that, in order to obtain the best purifying results, irrigation should always be combined with intermittent downward filtration. With regard to towns where a sufficiency of land cannot be procured for irrigating purposes, the process of downward filtration, as carried on at Merthyr Tydfil, should be adopted, and, in either case, the ashes and other town-refuse can be largely used in clarifying or disinfecting the sewage before it is delivered on the filtering ground. Trade or manufacturing pollution must be treated according to the nature of the pollution.

Where no sufficient amount of land can be procured, as in the case of numbers of large inland towns, recourse must be had to purification by some chemical process, but in many instances the difficulties are so enormous, that the pollution of neighbouring streams cannot be prevented, unless at a cost which would irretrievably ruin commercial enterprise. Even were all trade-refuse and sewage excluded from streams, the mere surface-washings of large towns are sufficient of themselves to convert many of them into foul rivers, which no legal enforcement of riparian rights nor any number of Rivers' Pollution Bills can ever render pure. Sanitary reformers are too apt to forget that, though streams and rivers may, and often do, prove valuable sources of water-supply, they are nevertheless the natural drainage outfalls of the country, and while many of them may be preserved from injurious pollution, there are numbers of others doomed to such an amount of pollution that, no matter what preventive means may be adopted, fish can scarcely live in them, and their turbid waters, however carefully purified, can never be safe to drink. It is evident, therefore, that with

regard to river pollution, the special circumstances of every large town involved in sewage-difficulties must be taken into account, and that no hard and fast rule can be enforced by Act of Parliament which shall be applicable to all alike.

SECTION III.—TREATMENT OF VILLAGE SLOPS.

Some slight reference has already been made to this part of the subject in the previous chapter, but the following remarks are submitted in the hope that they may prove of further service in assisting to clear up many of the difficulties in which this important question is involved. They are quoted from the pamphlet on Sanitary Defects in Rural Districts already alluded to, and are an attempt to explain the principles on which my own recommendations have been based, when local circumstances are taken into account:—

"If the village drains into a large stream which is not used for drinking purposes below the village, and provided there is no nuisance at the outfall, I have not considered it necessary to recommend any interference. If, again, the village drains into an open ditch without creating nuisance, it will generally be found that a large catch-pit will suffice, provided all excremental filth and slaughter-house refuse are kept out of the drains. But in all cases in which there is nuisance at the outfall, or risk of water pollution used for drinking purposes, I recommend that the sewage, if it be at all possible, should be purified by irrigation or sub-irrigation, and failing these that it should be filtered through a filter of sufficient size and on the intermittent downward filtration system. In some localities where the soil is

porous, and the quantity of sewage comparatively small, a dumb-well in a field will satisfactorily solve the difficulty, or the outfall drain may be carried alongside a field ditch of lower depth, and the soil between will act as a ready filter. Indeed, in purely agricultural districts, the various expedients which might be easily adopted for the purification and utilisation of village slops are so accessible, so to speak, that in the great majority of instances there not only need be no difficulty in treating them efficiently, but if properly utilised they will pay a fair return to any farmer who is public-spirited enough to take them. As a rule, however, the method of applying them to the soil is anything but satisfactory. Very often the quantity is so small that unless a tank is provided, which can be periodically emptied, the sewage trickles along the surface-gutter in the field, and finally disappears without contributing any of its fertilising properties, except it be to the sides of the gutter, on which some rank grass is found growing. But this insufficiency of volume, which constitutes the great objection which farmers have to village sewage, can easily be obviated by constructing one of Denton and Field's automatic sewage-meter tanks, in which the sewage can be collected for a period of twelve or twenty-four hours, according to the size of the tank, and by means of a self-acting syphon can be readily discharged when the tank becomes full. If land has to be purchased, half an acre to three-quarters of an acre of ground properly drained and laid out would be quite sufficient to purify the slops and refuse-water of a village containing 800 to 1000 inhabitants, provided the sewage is applied on this intermittent system, and the subsoil is porous. Of course, if simple

irrigation should be carried out, some three or four acres would be required, but in any case I should recommend the automatic sewage-meter tank to secure rapidity and intermittency of flow.

Sometimes the question is raised as to whether village-slops possess any agricultural value at all. For my own part, I am inclined to believe that they possess fertilising properties quite equal to those of ordinary town sewage; and as an instance in point I may mention that one of the rural sanitary authorities in my district receives a rental of about £6 an acre for a small field laid out in grass which was purchased for the purification and utilisation of the slops of an average-sized village. Indeed, any one who takes the trouble to use the household slops in the garden will soon find for himself that the increase in garden produce will more than compensate for the extra trouble. And here I may remark that part of the objections which farmers generally have to village sewage may be fairly attributed to their not unnatural opposition to any village improvements which are likely to increase the rates, and from which they do not receive any direct benefit. In places where both intermittent downward filtration and simple irrigation are objected to on account of their unsightliness, or the possibility of their giving rise to nuisance, the slops of a small village, if separated from the surface water, could be satisfactorily disposed of by sub-irrigation. In short, the difficulties to be encountered with regard to village drainage and purification of slops, as I have already said, are not so much engineering difficulties; the great difficulty in many rural districts is to get anything done at all in this direction.

In sub-irrigation, the drains consist of common agricultural pipes laid at a depth of about 12 inches below the surface upon a bed of larger pipes divided longitudinally in half, so that the slops soak through between the open joints into the subsoil, part of them filtering into the ground and part of them being absorbed by the vegetation on the surface. The system may be used in gardens, and is specially applicable to land which is reserved for pasture land. Mr. Field recommends that the drains should be taken up and relaid at least once a year, and it is always advisable to have the subsoil deep-drained. Where the system is adopted, as at Shenfield near Brentwood, for separate houses or groups of houses, care must be taken to avoid pollution of the wells, by laying a longer or shorter portion of water-tight drain, according to circumstances, between the flush-tank and the sub-irrigation drains.

CHAPTER XIII.

THE EFFECTS OF IMPROVED DRAINAGE AND SEWERAGE ON PUBLIC HEALTH.

THIS subject may be conveniently considered as follows:

1. The effects of dampness of soil on the public health.
2. The sanitary aspects of the water-carriage system of excretal removal.
3. The sanitary aspects of sewage-irrigation.

SECTION I.—THE EFFECTS OF DAMPNESS OF SOIL ON PUBLIC HEALTH.

Amongst the numerous valuable reports which Dr. Buchanan, in his capacity of Health-Inspector, has submitted to the Privy Council, there is perhaps none which excited greater interest at the time than his report "On the Distribution of Phthisis as affected by Dampness of Soil." In a previous investigation regarding the effects of improvements in drainage and water-supply, Dr. Buchanan had ascertained that in certain towns which had been improved in this respect, the mortality from phthisis had greatly diminished; and not only so, but the rate of diminution was found to correspond with the extent of the drying of the subsoil. This result, which was so far unexpected, led to the important inquiry above mentioned, and the principal

facts connected with both may be briefly summarised as follows:—

In the first inquiry, it was found that wherever the drying of the subsoil had been effected, either by the construction of drain-sewers, or by special drains and deep storm-culverts, when the pipe-system was carried out, the mortality from phthisis had decreased from about 50 per cent downwards. In Salisbury, for example, the death-rates from phthisis had fallen 49 per cent; in Ely, 47; in Rugby, 43; in Banbury, 41; and in 13 other towns, the rate of diminution, though not so marked, was nevertheless noteworthy. On the other hand, it also became apparent that in certain towns, such as Alnwick, Stafford, Morpeth, and Ashley, where no drying of the subsoil had been effected, there was no reduction in the phthisis death-rate, even although the greatest possible progress had been achieved in the removal of filth. This was owing to the fact, that in these towns impervious pipe-sewers had been laid down, without making any provision for deep subsoil-draining, the storm-water being carried off in superficial culverts. In some towns, again, such as Penzance, where the subsoil was already dry, the phthisis death-rate remained stationary; and in others, where plans of drainage had been carried out, the sanitary advantages, as regards phthisis, were nullified, because, as in the case of Carlisle, they were so low-lying that the subsoil was at all times more or less water-logged. So far, therefore, the relation between dampness of soil and phthisis, as one of cause and effect, became highly probable, and Dr. Buchanan's second inquiry converted the probability into a scientific certainty.

In this special inquiry (see *Tenth Report of the Medical Officer of the Privy Council*) the various registration districts in the three south-eastern counties of England, beyond the limits of the metropolis, were brought under detailed examination, and considered in two ways. Firstly, the true phthisis-rate of the population was ascertained, and due allowance made for the causes of the disease which were likely to influence the rate besides the nature of the soil; and secondly, the numbers of the population, in each district, that were found "living upon various kinds of soil, and under various topographical conditions," were also noted. The results of these two separate lines of investigation were then brought together, and statistically compared.

Without entering into any of the geological details, which are fully given in Dr. Buchanan's report, it may be said, generally, that the dampness or dryness of a soil depends partly on whether, if pervious, it is retentive of water, or, if impervious, the water can readily drain away. Again, it is obvious that pervious soils may present very different degrees of dryness or wetness, according to the elevation of the ground, and the dip of underlying impervious beds. Thus, a stratum of gravel or chalk, covering a sloping bed of impervious clay, is necessarily a dry soil, because the rainfall readily sinks to and flows along the surface of the impervious slope, whereas the same stratum in a valley may be actually waterlogged, although the depth of the stratum may be the same throughout. Bearing in mind, then, the topographical relations as well as the physical qualities of different soils, the following general conclusions, given by Dr. Buchanan as the result of his inquiry, will be at once understood:—

"(1.) Within the counties of Surrey, Kent, and Sussex, there is, broadly speaking, less phthisis among populations living on pervious soils than among populations living on impervious soils.

"(2.) Within the same counties there is less phthisis among populations living on high-lying pervious soils than among populations living on low-lying pervious soils.

"(3.) Within the same counties there is less phthisis among populations living on sloping impervious soils than among populations living on flat impervious soils.

"(4.) The connection between soil and phthisis has been established in this inquiry—

"(*a*) By the existence of general agreement in phthisis-mortality between districts that have common geological and topographical features, of a nature to affect the water-holding quality of the soil;

"(*b*) By the existence of general disagreement between districts that are differently circumstanced in regard of such features; and

"(*c*) By the discovery of pretty regular concomitancy in the fluctuation of the two conditions, from much phthisis with much wetness of soil to little phthisis with little wetness of soil.

"(5.) The whole of the foregoing conclusions combine into one—which may now be affirmed generally, and not only of particular districts—that wetness of soil is a cause of phthisis to the population living upon it."

It is interesting to note that this new discovery in the etiology of disease, which in this country has been associated with Dr. Buchanan's name, had already been brought to the notice of the profession in America by Dr. Bowditch of Boston, U. S. It would appear, how-

ever, that Dr. Bowditch's researches were not known in England until after Dr. Buchanan's inquiry had been finished: and although the priority rests with him, the credit of independently establishing causation of phthisis by dampness of soil as a general law remains with Dr. Buchanan. But it would be unfair not to quote Dr. Bowditch's own remarks. In a very able and lucid address delivered to the Massachusetts Medical Society in 1862, he submitted the two following propositions as containing the essential results of very extended inquiry:—

"First.—A residence in or near a damp soil, whether that dampness be inherent in the soil itself, or caused by percolation from adjacent ponds, rivers, meadows, marshes, or springy soils, is one of the principal causes of consumption in Massachusetts, probably in New England, and possibly in other portions of the globe.

"Second.—Consumption can be checked in its career, and possibly, nay probably, prevented in some instances, by attention to this law."

But in order perhaps not to wish to appear too dogmatical, he qualifies these propositions farther on by the following statement:—"Medical opinion in Massachusetts, as deduced from the written statements of resident physicians in 183 towns, tends strongly to prove, though perhaps not affording perfect proof of, the existence of a law, in the development of consumption in Massachusetts, which law has for its central idea that dampness of the soil of any township or locality is intimately connected, and probably as cause and effect, with the prevalence of consumption in that township or locality." (See *Medical Communications of the Mass. Med. Soc.* vol. x. No. II.)

But, in addition to phthisis, there are other diseases whose prevalency is largely affected by dampness of soil. Thus, rheumatism, heart-disease, catarrhal complaints, and ague, are especially common in damp districts; and no greater proof can be given of the sanitary advantages arising from drainage on an extensive scale than the total disappearance of the last-named disease in various parts of the country where it was at one time so common. Moreover, it is evident that in towns situated on damp pervious soils, there is the constant danger of filth-accumulations finding their way by soakage into surface-wells, or, as has previously been shown, the soil may eventually become excrement-sodden, so that the air, as well as the well-water, becomes polluted. It is in this sense that the views of Pettenkofer with regard to the spread of cholera and enteric fever become so important, for he insists on humidity of soil as a necessary factor in the etiology of any localised outbreak of either disease.

An undrained or damp state of soil, especially in populous places, is thus fully proved to be highly inimical to public health, and, according to Mr. Simon, it answers to the legal definition of the term "nuisance." Sanitary authorities are therefore "bound to provide that such a state shall not continue through want of proper constructions for the drainage."

Section II.—Sanitary Aspects of the Water-Carriage System of Excretal Removal.

So much has already been said with regard to the evils resulting from collections of excretal matter in towns, that, at first sight, the superiority of any system

which prevents these accumulations would appear to be placed beyond dispute. Unfortunately, however, the sewer-system is by no means free from serious dangers, and these have at times been attended with such disastrous consequences that many have been led to condemn it altogether. But an examination of a few of the more important outbreaks of disease, which have been attributed to the introduction of sewers, will show that such wholesale condemnation is groundless; that in fact such outbreaks are due to faults in the system, and not to the system itself. Thus, in the first inqury of Dr. Buchanan, already alluded to (*Ninth Report of the Medical Officer to the Privy Council*), it was found that at Chelmsford the death-rate from enteric fever had increased, since the introduction of the sewer-system, 5 per cent, and at Worthing it had increased 23 per cent. In both these places, however, there was backing up of the sewage, and, as a consequence, the sewer-gases were forced up into the houses. At Chelmsford, the sewage was received into a tank or underground well; and, at times, when the pumping-engine was not at work, the well filled, and choking of the outfall-sewer, and flooding of the cellars, ensued. At Worthing, again, although there was not so much backing up of the sewage, there was no provision made for ventilation; and hence, in the outbreak of 1865, the disease "almost exclusively attacked the well-to-do occupants of houses on the higher levels, where the water-closets were inside the houses, and almost entirely spared the houses, mostly of a much poorer sort, situated on lower levels, where the closet was placed outside the house. It was not so in the times of cess-pools; then these low-lying poor hou[illegible]

attacked with fever than the others." At Morpeth it was also observed that occasional outbreaks of enteric fever had followed times of flood, during which the outfall sewer was under water.

Other instances of a similar character might easily be multiplied, but these are sufficient to show that all such outbreaks are due either to faulty construction, deficient ventilation, or imperfect flushing of sewers, or to backing up of sewage in low-lying towns. But while outbreaks of enteric fever do occasionally take place through the agency of sewers, and amongst others may be mentioned the outbreak at Croydon in 1875, there was no point more clearly established in the whole of Dr. Buchanan's inquiry, than the remarkable reduction of the death-rate from this disease which had taken place in almost all the towns where a proper system of sewerage had been carried out. Thus, in nine of the twenty-five towns examined, the diminution in the number of deaths was over 50 per cent, and in ten others from 33 to 50 per cent, the average reduction being about 45 per cent. The same kind of evidence is also afforded in the account of the sanitary condition of Liverpool, given by Dr. Trench in 1868. Dr. Trench writes:—In 1868 "there raged a widespread epidemic of typhoid fever in the town, and in the rural districts of the town. . . . While in the families of the rich, in their costly suburban dwellings, there was raging a fever, clearly and unmistakably due to the pestiferous emanations from ill-drained cesspools, or other collections of filth or decomposing organic matter; the districts in the borough of Liverpool known as the fever districts, and wherein no midden-steads or cesspools were allowed by the Council to remain un-

altered, continued, during the whole period of the epidemic, remarkably healthy and free from fever."

As regards other diseases, it appears that cholera epidemics had been "rendered practically harmless" in all of the twenty-five towns examined by Dr. Buchanan; and in the majority of cases the death-rate from diarrhœa had also been considerably reduced. Moreover, the general death-rate was lowered in some towns over 20 per cent; and the progress made by the inhabitants in cleanliness, decency, and self-respect, was found to be as striking as the improvement in their health measured by the mortuary returns. No doubt, the improved water-supply, which was generally obtained at the same time, aided in the common health-amelioration, but there can be little question that the system of excretal removal by water-closets and sewers was the real agent at work.

SECTION III.—SANITARY ASPECTS OF SEWAGE IRRIGATION.

It has already been shown in the previous chapter that irrigation is the only method of sewage-disposal which sufficiently purifies the sewage, and, at the same time, secures a profitable agricultural return. It now remains to be seen whether the carrying out of the system is attended with danger to public health. And here it may be premised that the same difficulty is encountered in sifting evidence as throughout the whole sewage-question,—the difficulty, namely, of dealing with sweeping generalisations which have been based on isolated or exceptional cases. For while, on the one hand, it appears that Dr. Letheby and others have con-

demned all sewage farms as pestilential swamps, Dr. Carpenter of Croydon and other strenuous advocates of the system, so far from pronouncing them as in any way dangerous to health, maintain that the general health of the neighbouring inhabitants is actually improved by them. But this is pushing the argument perhaps too far on both sides. No doubt some sewage farms answer to Dr. Letheby's description, especially such farms as have been laid out, without any due regard to drainage, in low-lying districts, and those that have been planned on the "catch-water" system. It is evident that this latter system necessitates a swampy condition of both soil and subsoil, unless the ground is porous and well-drained, inasmuch as the sewage passes over successive areas of land, overflowing from each into a "catch-water" ditch, which conveys it to the next. Again, when the sewage is not delivered in a fresh state, and at least properly strained, if not disinfected by some precipitation process, offensive emanations are undoubtedly given off, especially when the carriers are not kept clean. But though all this is perfectly true, it is no argument against the system when properly carried out, unless direct evidence can be brought forward to show that, even when the engineering and management are alike satisfactory, there is not only possible but actual risk to health. Such evidence, however, does not appear to be forthcoming; and even with regard to farms which have neither been planned nor are conducted according to the most approved principles, the evidence as regards the production of disease is of a negative character. Thus, Sir Robert Christison testifies concerning the Craigentinny Meadows, near Edinburgh—"I am satisfied neither typhus, nor

enteric fever, nor dysentery, nor cholera, is to be encountered in or around them, whether in epidemic or non-epidemic seasons, more than in any other agricultural district of the neighbourhood." (*First Report of the Rivers' Pollution Commissioners.*) At Norwood, again, where the farm lies on a deep clay soil, Dr. Cresswell states that the health of the neighbouring inhabitants is in no way influenced by it; and according to the Ninth Report of the Medical Officer of the Privy Council, the irrigation works at Worthing do not cause any description of nuisance or injury to health. So far, therefore, the production of disease arising from fæcal pollution of air or water by the system, when properly managed, is not substantiated. But it was feared at one time that entozootic diseases would be greatly propagated, no matter how efficiently the system might be carried out, and Dr. Cobbold's high authority gave currency to the belief. Dr. Cobbold, however, with rare scientific candour, and after careful investigation, has since stated that the fears which he originally entertained have not been realised. Animals fed on sewage produce have not been found to be parasitically diseased, nor has any case of parasitism been detected in man which could be traced to the effects of sewage-irrigation.

Alarmists, too, have not been wanting, who strenuously maintain that the milk of cows fed on sewaged grass is poor in quality, rapidly decomposes, and is unfit to be used. But so far is this from being the case, that there is an overwhelming amount of evidence to the contrary, and amongst other instances I may mention the following:—Dr. Brushfield, of Brookwood Asylum, writes me to say that he has tried the experi-

ment, and found that cows fed on sewaged grass yield more and richer milk than cows fed on ordinary pasture, and this is also the experience of Mr. Tough, the manager of Lord Warwick's farm. Further, Dr. Hill of Birmingham and Dr. Swete of Leamington have frequently analysed both milk and butter, and with the most satisfactory results. It need hardly be said, that on a well-conducted sewage farm, no sewage is applied for several days before the grass is mown, so that it is always perfectly clean.

General Conclusions.—Having regard to the practical as well as sanitary aspects of the whole of this subject, the following points of detail may be noticed:—

1. All towns and villages situated on a pervious or damp soil should be drained.

2. Where there is a good outfall, and no difficulty with regard to the disposal of the sewage, drain-sewers will suffice for drainage as well as for sewage-removal.

3. In low-lying towns, and where the sewage has to be pumped to a higher level at the outfall, pipe-sewers are required.

4. Towns supplied with pipe-sewers should have a separate system of drainage for the removal of the storm and subsoil water.

5. Wherever it is practicable, the sewage should be purified and utilised by the process of irrigation, or, where sufficient land cannot be procured, by intermittent downward filtration. Purification by either process will be greatly assisted by previously treating the sewage according to one or other of the most approved precipitation-processes.

CHAPTER XIV.

PREVENTIVE MEASURES—DISINFECTION.

The remarks in this chapter will have reference chiefly to the prevention of infectious diseases, and to the adoption of measures best calculated to check their progress when they become epidemic, or threaten to become epidemic, in any locality. By infectious diseases is meant all diseases which are communicable from one person to another, whether by actual contact or through the agency of certain media, such as air or water. Many of these, however, are comparatively of such little hygienic concern, that they may be excluded from further notice; as, for example, certain parasitic diseases of the skin, and others, which are never found to affect communities in an epidemic form. The preventive measures, therefore, or other protective means, which will be here considered, apply mainly to the class of diseases termed zymotic, such as smallpox, cholera, typhus fever, enteric fever, scarlet fever, relapsing fever, measles, and the like. Although, in preceding chapters, the mode of propagation of several of these diseases has been considered more or less fully in detail, it will nevertheless be of advantage to allude very briefly to some of the opinions which are entertained concerning their etiology. According to the germ or parasitic theory of infectious diseases, the origin, *de novo*, of a fever poison

is as impossible as the spontaneous generation of plants or animals; the inference being that enteric fever, for example, can only be developed from the specific contagium of the fever, just as a case of smallpox cannot occur without infection from some pre-existing case. Now to this it may be replied that the poisons of all the acute specific diseases must have originated at one time or another independently of pre-existing cases, and there is no reason to believe, therefore, that the causes which led to the development of the first cases should not be in operation at the present day.

The fact is, as Dr. Murchison has pointed out, the question at issue has been discussed on too narrow a basis, and the possibility of the several zymotic diseases differing greatly has been too much lost sight of. Just because all of them are infectious, it has been argued that none of them can be generated except by a specific contagium. But even as regards this infectious quality, there is the widest possible divergence between them; for while, on the one hand, we find that smallpox and scarlet fever are extremely infectious, we find, on the other, that enteric fever, diphtheria, and erysipelas, have only a limited power of propagating themselves, except under insanitary conditions which are favourable to their development and spread. Moreover, while, in regard to smallpox, it can never at the present day be traced to any other cause than infection, in diphtheria, it is comparatively rarely that the first case, even of several, can be traced back to any pre-existing case; and the same remark applies generally to sporadic cases or limited outbreaks of enteric fever as they occur in rural and small urban districts. Then, again, it is a matter of almost daily observation that pyæmia and

puerperal fever are not only generated *de novo*, but the researches, more especially of Dr. Sanderson, show that they can be generated at will, and when so generated they become, under certain circumstances, eminently infectious. It is no argument, therefore, that because a disease is infectious it cannot be generated *de novo*, and the argument becomes weaker still when it is remembered that several of these diseases do not breed true, nor do they run a definite course. Thus we find erysipelas and pyæmia running into each other, and that either of these, or scarlet fever in its varied forms, may generate puerperal fever in the parturient woman. Without, however, entering farther into the speculative or scientific aspects of this question, I prefer quoting the matured views of Mr. Simon. After dilating upon the influence which filth, and more especially excremental filth, exercises in the development and spread of diseases such as cholera and enteric fever, which, in respect of their leading symptom, may be generalised as diarrhœal, Mr. Simon continues—

"But though hitherto, for convenience of argument, I have referred specially to the influence of human excrement in determining the spread of 'specific' infections from man to man, and provisionally as if man's body were the sole birthplace of the several contagia which afflict his kind, assuredly that intermediary influence is but part, and it may be but a very subordinate part, of the faculty by which filth produces disease. While it is indeed true, as regards some contagia, that at present we know them only as incidents of the human body, wherein we see them in case after case multiplying their respective types with a successivity as definite and identical as that of the highest

orders of animal or vegetable life,—and while thus it is at present true, for instance, of smallpox or syphilis, that a case arising independently of a previous like case is hitherto practically as unknown to us as the parentless production of dog or cat, our knowledge with regard to other very important contagia is growing to be of larger scope. I would mention it as among the most hopeful advances of modern preventive medicine, that some diseases, which, in the sense of being able to continue their species from man to man, are apparently as 'specific' as those which I have above named, seem now beginning to confess in detail a birthplace exterior to man, a birthplace amid controllable conditions in the physical nature which is around us, a birthplace amid the 'common,' putrefactive changes of dead organic matter. Referring again now to what I have not pretended to be able to analyse in detail—the excess of miscellaneous, and in great part nominally 'common,' disease in filthy neighbourhoods, I would particularly wish to connect with that subject a reference to our growing scientific knowledge in the matter of the 'common' septic ferment. The pathological studies of late years, including eminently certain very instructive researches which Professor Sanderson has conducted under my Lords of the Council, have clearly shown that in the 'common' septic ferment, or in some ferment or ferments not hitherto to be separated from it, there reside powers of disease-production as positive, though not hitherto as exactly defined, as those which reside in the variolous and syphilitic contagia. Experimentally we know of this ferment, that, when it is enabled by artificial inoculations to act in its most effective way on the animal body, and even more when

it has received a curious increment of strength which its first propagation within the living body seems to bestow on it, it shows itself one of the most tremendous of zymotic poisons. It rapidly in the one animal body develops disease, which then is communicable to another: febrile disease, with inflammations numerous and intense, and including in marked degree one of the acutest known forms of intestinal inflammation and flux: disease exactly corresponding to certain very fatal and unfortunately not unfrequent infections to which lying-in women, and persons with accidental wounds and the wounds of surgical operations, are most subject, but which also sometimes occur independently of such exceptional states; infections, chiefly known under the names of erysipelas, pyæmia, septicæmia, and puerperal fever; infections which we sometimes see locally arising anew in unquestionable dependence on filth, but of some of which, when arisen, it is perfectly well known that they are among the most communicable of diseases. And a further, perhaps still more instructive, teaching of the artificial infections is this: that the 'common' ferment, which in its stronger actions quickly destroys life by septicæmia, can in slighter actions start in the infected body chronic processes which will eventuate in general tubercular disease. I need hardly point out that the above facts, extremely suggestive though they are, must of course, in relation to my main argument, be applied only under certain reserve; that evidently the exact conditions of the physiological experiment are not reproduced in ordinary life; and that against the common septic ferment, as presented in fouled atmosphere or fouled drinking water, the living human body in its normal state can

apparently make considerable (though presumably not unlimited) resistance. But after all such reserves the truth remains, that, looking well at the pathology of human life under residence in foul air, we find ourselves again and again reminded of these results of physiological experiment: often seeing phthisis and other tubercular and like diseases gradually developed, as though under gradual overpowering of the limited normal resistance to the septic ferment; or seeing—and particularly where some exceptional bodily state (wounded or puerperal) gives opportunity—the sudden invasion of erysipelas or other septic infection, not in discoverable dependence on any human infectant, but conceivably a filth-inoculation from the air. The line of reflection thus suggested is one which I cannot now follow further, but of which the practical interest seems to be extremely great. For, while the excessive production of fatal disease in filthy neighbourhoods is a fact as to which there can be no doubt, and of which the immediate significance is deplorable, the ulterior suggestion is this: that so far as filth in any instance produces anew such a disease as erysipelas or puerperal fever on the one hand, or phthisis or other tubercular disease on the other, the mischief first done is of a sort which entails certain possibilities of extension: such, namely, that in the one instance by accidental contagion, as in the other instance by hereditary transmission, it may, for aught we know, indefinitely extend beyond the sphere in which filth first produced it." (See Mr. Simon's *Reports*, New Series, No. II.)

But apart from the influence of sanitary defects in the development and spread of infectious diseases, and apart also from the influence of personal susceptibility,

which as regards some of them is very great, there are certain other influences obscurely called epidemic, which appear to act as predisposing causes, or, at all events, to give increased energy to causes already in operation. Such epidemic influence, however, is merely the expression of the fact that we cannot always explain why it is that certain diseases should rage with terrible violence in a particular locality at one time and not at another; or why the type of the disease should now be mild and now severe; or why again, a disease, such as cholera, should be subject to periods of pandemic extension. All these are questions which still afford ample room for speculation and research. Meanwhile it is encouraging to sanitary efforts to find that as civilisation advances, epidemics decrease in frequency and intensity, and that nothing tends so much to weaken their power and circumscribe their range of action, as a free circulation of pure air in inhabited places a good supply of pure water, and a sufficiency of wholesome food.

In preceding chapters the mode of propagation of several of these diseases has been considered more or less fully in detail. It has been shown, for example, that there is good reason to believe that the contagia of cholera and enteric fever are contained in the alvine discharges, which, in their turn, pollute the water-supply or the respired air; that typhus fever is essentially a disease of overcrowding; and that relapsing fever is associated with wide-spread insufficiency of food. It has also been shown, that when the local circumstances which are found to favour the propagation of any one or other of these diseases in an epidemic form are improved, the extension of the disease is checked, and its ultimate extinction from a portion of the community

secured. Improvement of local circumstances is, therefore, a most important, and perhaps the most important, part of prevention. But there are other measures which are found to be of immense service in checking the course of any epidemic,—such as the isolation of the sick, the use of disinfectants, and the destruction of the contagia by any other means which may be deemed most efficacious. In order, however, to be able to apply these measures judiciously, some knowledge of the mode of propagation of the several epidemic diseases is essential, and this part of the subject may be briefly discussed as follows:—

Section I.—Mode of Propagation of Epidemic Diseases, and the Precautionary Measures indicated.

1. *Cholera.*—The basis of precautionary measures with regard to this disease is thus described by Mr. Simon:—"That, when cholera is epidemic in any place, persons who are suffering from the epidemic influence, though perhaps with only the slightest degree of diarrhœa, may, if they migrate, be the means of conveying to other places an infection of indefinite severity; that the quality of infectiveness belongs particularly, if not exclusively, to the matters which the patient discharges, by purging and vomiting, from his intestinal canal; that the matters are comparatively non-infective at the moment when they are discharged, but subsequently, while undergoing decomposition, acquire their maximum of infective power; that choleraic discharges, if cast away without previous disinfection, impart their own infective quality to the excremental matters with which

they mingle, in drains or cesspools, or wherever else they flow or soak, and to the effluvia which those matters evolve; that if the cholera-contagium, by leakage or soakage from drains or cesspools, or otherwise, gets access, even in small quantity, to wells or other soures of drinking-water, it infects, in the most dangerous manner, very large volumes of the fluid; that in the above-described ways even a single patient with slight choleraic diarrhœa may exert a powerful infective influence on masses of population among whom perhaps his presence is unsuspected; that things, such as bedding and clothing, which have been imbued with choleraic discharges, and not afterwards fully disinfected, may long retain their infectious properties, and be the means of exciting choleraic outbreaks wherever they are sent for washing or other purposes." (*Eighth Report of the Medical Officer of the Privy Council.*)

The practical applications of the above remarks are therefore these,—that the alvine discharges and vomited matters, as well as any clothing or bedding tainted by them, should be carefully disinfected; and that, if this is carefully attended to, there is little or no risk of infection by direct contact with the patient.

It would be out of place here to refer except in the briefest terms to the various conflicting doctrines which have been advanced with regard to the propagation of this disease. Suffice it to say, that while Mr. Simon's views are in full accordance with the experience of those who have most carefully investigated its etiology in this country, the views more especially of Dr. Cunningham, the Sanitary Commissioner of the Government of India, are so entirely opposed to them that it would appear as if the results of all the inquiries which have

been so carefully made are absolutely worthless, and that previous investigators have been on the wrong track. In the Ninth Annual Sanitary Report to the Indian Government, he declares in effect, on the evidence of 108 outbreaks, that the transportability of cholera by persons is erroneous, that the water-spread of the disease is untenable, and that the influence of tainted air cannot be at present affirmed. According to him, so little is known about the epidemic extension of the disease, that preventive measures are practically of little or no value. It is satisfactory to note, however, that even in India, these views are already beginning to receive substantial refutation; for in his report for the second quarter of 1876, Dr. Payne, the medical officer of health for Calcutta, shows clearly that though other insanitary conditions in the native parts of the city remain unaltered, the introduction of a public water-supply, which took place in 1870, has been followed by a remarkable and continuous diminution in the spread of cholera. Pettenkofer's views have already been alluded to in Chapters VIII. and XIII.; and those who are desirous of studying the European relations of the disease, should read the elaborate report of Mr. Netten Radcliffe, and the abstract by Dr. Seaton of the proceedings of the International Congress held at Vienna in 1874, both of which are contained in No. V. of the New Series of Mr. Simon's *Reports*.

2. *Enteric or Typhoid Fever.*—That this disease is essentially a filth-disease is alike admitted by those who accept the doctrine of Von Gietl and Dr. Budd, and those who, like Dr. Murchison and Sir William Jenner, maintain that it may be generated independently of previous cases. As it occurs in rural and

small urban districts, my own experience leads me to believe that the great majority of scattered cases, and many of the first cases of isolated outbreaks, are due to poisoning of air, drinking-water, or other ingesta with decomposing filth. Most frequently it is found that the well-water has become polluted by soakage from some drain, cesspit, or manure heap, and in some instances it would appear as if ill-defined forms of enteric fever, such as those vaguely termed low fever, gastric fever, febricula, and the like, may be caused by decomposing organic matter not necessarily fæcal. But whether the disease is produced by befouled air or polluted water, there is a constantly accumulating amount of evidence which goes to prove that neither the air nor the water need be tainted with the specific contagium of the disease. At the same time, there is no fact more clearly established in preventive medicine than this,—that whenever the disease is developed, the bowel discharges possess an infective power, which, where local conditions assist, can operate with terrible force, and often at long distances from the sick. Indeed, exclusive of the epidemic influence, what has been said with regard to the infective power and the mode of propagation of cholera, applies to enteric fever, and, in the main, the same precautionary measures (see Appendix) are indicated. The evacuations, and any clothing tainted with them, should be thoroughly disinfected. The water-supply should be examined, and in localities where the sewer-system has been introduced, the condition of the water-closets and drains, with regard to ventilation and trapping, should be carefully inquired into. Any epidemic of enteric fever in a sewered town points to imperfect ventilation,

deficient flushing, or to some faulty construction of the sewers or drains, or to contamination of the water-supply, as in the outbreaks of Sherbourne, Over Darwen, and Lewes (see Chap. VIII.); or to polluted milk, as in the outbreaks in Marylebone, East Moseley, and Eagley (see Chap. II.) In villages and country districts it points to polluted wells, bad drainage, or filthy privies, all of which may originate the disease in the first instance as well as be the means of propagating the specific contagium when it is developed or introduced.

If proper precautions are taken, there is little or no risk that the disease will spread to persons who nurse or otherwise closely attend upon the sick.

3. *Typhus Fever.*—The conditions essential to the propagation of typhus fever are mainly these:—over-crowding and deficient ventilation; clothing saturated with cutaneous exhalations; squalor and want; a deteriorated state of the constitution from whatever causes; and a moderate temperature.

The disease, once generated, is highly contagious, the contagium being thrown off by the cutaneous and respiratory exhalations. The air of the sick-room is therefore contaminated, and by this means the contagium may attach itself to the walls of the room, or to furniture, or to bedding and clothing, and may long retain its efficacy if fresh air is excluded. Cases are not at all uncommon in which the disease has been communicated to persons who have been employed in cleaning out places which had been occupied by the sick, even though some considerable time had elapsed after the sick had been removed.

But the contagium does not travel far through the air, for, according to Dr. Murchison's observations, it

appears that if a patient is placed in a well-ventilated room, the attendants incur little risk, and the other occupants of the house none whatever. Dr. Russell, medical officer of health for the City of Glasgow, has also reported to the same effect, and has, in addition, deduced from his experience other points of practical importance. Thus, in his report on the Fever Hospital for 1870, he writes—"All these facts concur in proving (1) that, where attention is paid to personal and general cleanliness, typhus does not carry far, so to speak, through the atmosphere, and is not portable; (2) close approach to, and contact with, the infected individual and his dirty belongings, lead with great certainty, even in the best sanitary circumstances, and in healthy and well-fed people, to an attack at the end of about four weeks in the great majority of cases, but not in a few until the lapse of some months; (3) that individual susceptibility does not exist, except that which is conferred by a previous attack."

As regards the period of the disease at which the contagium is most powerful, there is a difference of opinion. Dr. Murchison believes that the disease is most readily propagated from the end of the first week up to convalescence—that is, during the period when the peculiar typhus smell from the skin and lungs is the strongest.

The practical deductions from these observations are as follows:—The sick should be isolated as much as possible; the attendants, by preference, should be those who have been protected by a previous attack; others who visit the sick should avoid coming into close contact with them; the room should be well ventilated by open windows and fires if necessary; all extraneous

furniture, such as carpets and curtains, should be removed and disinfected; disinfectants should be constantly used in the room; the bedding and clothing should be disinfected or destroyed; and after convalescence, the whole room, and every piece of furniture, should be purified.

4. *Relapsing Fever.*—Excluding for the present the consideration of the public measures which should be adopted when an epidemic of relapsing fever is raging, the hygiene of the sick-room should be conducted in the same manner as in the case of typhus fever. The disease, however, is much less frequent than typhus, and though contagious in the same way, is not contagious to the same extent. It selects its victims from the poor and ill-fed, who live in crowded, unventilated buildings, rather than from the well-nourished, whose surroundings are healthy.

5. *Smallpox.*—"There is no contagion," writes Sir Thomas Watson, "so strong and sure as that of smallpox; none that operates at so great distance." The contagium indeed may be wafted from house to house on opposite sides of a street, and even with every sanitary precaution, there is great difficulty in preventing its spreading from ward to ward in a large hospital when the disease is prevalent. The poisonous material is thrown off from the cutaneous and mucous surfaces of the patient, and is contained in the exhalations, the excretions, the secretions, the matters in the vesicles and pustules, and in the scabs. It contaminates the air of the sick-room, and attaches itself, as in typhus, to everything contained in the room, or which comes in contact with the patient. Further, it is possessed of great vitality, and if protected from air may remain active for an unknown number of years. (*Aitken.*)

The stage of the disease at which the poison is first generated in the person of the sick is not accurately determined, but there cannot be the slightest doubt that, so soon as a case is diagnosed, precautionary measures should forthwith be adopted. If the patient is not at once removed to a hospital, he should be carefully isolated; those in attendance on him should if possible be protected by a previous attack of smallpox or by revaccination; and the same details with regard to the hygiene of the sick-room, disinfection, etc., should be observed as have already been insisted on in cases of typhus. Concerning the protection afforded by vaccination and revaccination, as well as other points of public importance, see Appendix.

6. *Scarlet Fever.*—Although this disease may attack persons of all ages, it specially attacks children between the third and fourth year; after the fifth year the chances of attack decline rapidly. The contagium, like that of smallpox, is exceedingly powerful and volatile, so that no susceptible person can remain in the same room for any length of time, or even in the same house, unless the patient is carefully isolated, without running great risk of contracting the disease. Moreover, the contagium is contained in everything which proceeds from the patient, but more especially in the cuticular scales given off in desquamation. These scales, laden with the specific poison, are conveyed by the currents of air to every part of the room, and may settle on clothing, bedding, furniture, walls, etc. They preserve their virulence for an unknown period of time, and when disturbed are always liable to reproduce the disease. Thus, there are several instances recorded in which the fever has been contracted by sleeping in a room, which weeks

previously had been occupied by a scarlet fever patient; and the fact that the poison adheres to articles of clothing is proved by instances in which the disease has been propagated by the clothing of pupils returning home from school. The cases already referred to in the chapter on water impurities are also of great interest in showing the absolute necessity of the utmost care and cleanliness to be observed on all occasions, whether the attack is mild or severe. In the vast majority of cases, a previous attack confers permanent immunity from the disease.

The precautionary measures which are indicated by the above remarks are obvious; although it may be admitted that it is impossible to carry them out efficiently in the crowded homes of the poorer classes. But even in homes where no difficulty should be experienced, the necessary isolation and disinfection are too often grossly neglected, either because they are irksome, or, if the case is slight, because they are considered to be needless. With regard to special precautions, see Appendix.

7. *Measles.*—This disease, like scarlet fever, is eminently communicable. The contagium may be conveyed by *fomites*, or by means of the contaminated air of the sick-room. The disease attacks persons of all ages and of both sexes, but is much more frequent amongst children. The risk of infecting commences with the primary fever, and is greatest when the specific eruption is fully developed. As a rule, a patient who has once suffered from the disease is no longer liable to a second attack.

8. *Hooping-Cough.*—The susceptibility to this disease is so strong that few persons have passed the age of childhood without having contracted it. Moreover, the

infecting distance of the contagium appears to be very considerable, inasmuch as domestic isolation is frequently found to be of little avail in preventing the disease from attacking other members of the family who have not been protected by a previous illness. That the contagium may likewise adhere to clothing, and may in this way propagate the disease, has been clearly proved by numerous instances.

Such being the mode of propagation of measles and hooping-cough, the precautionary measures which are indicated comprise—isolation of the patient, if other members of the family have not been protected by a previous attack; careful attention to the hygiene of the sick-room; and disinfection of the clothing, bedding, etc. And here it may be pointed out that the prevalence of these two diseases is in great measure attributable to the culpable neglect, arising from the popular belief, amounting almost to fatalism, that children must contract them some time, and that there is therefore little use in endeavouring to take any protective steps when either disease is epidemic. The consequence is that the epidemic continues to spread so long as susceptible victims are to be found in the community, and only dies out for a time when almost all these have been attacked. How far the medical profession are to blame in allowing this popular delusion to retain its hold on the public mind, it would be difficult to say, but until they unite in striving to get rid of the listless apathy which it engenders, the prevalence of such epidemic diseases will continue to be an opprobrium to sanitary science. Nor must it be forgotten that medical men, in the hurry of practice, do sometimes, though unwittingly, convey the contagium of an infectious

disease from one patient to another. For example, instances are not at all uncommon in which scarlet fever has been propagated in this way, and the records of puerperal fever contain the histories of many painful cases which could never have occurred had greater care been taken to guard against such fatal mishaps.

With regard to other infectious diseases which are not so liable to spread in an epidemic form, little need be said. Diphtheria requires that the sputum and handkerchiefs or rags used to wipe the mouth of the patient should be disinfected or destroyed, and injunctions should be given to attendants not to bend over the patient, so as to run the risk of inhaling the breath. Further, as there are good grounds for believing that the disease is sometimes originated by impure water or defective sewerage, these should both be looked to and remedied.

In these remarks on the mode of propagation of infectious disease, it has been assumed throughout that the body of the diseased person is the soil in which the germs or infective particles of the disease are multiplied; that these germs, whatever be their nature, are given off by the patient, and may contaminate the air, drinking-water, or other ingesta, or may adhere to clothing, bedding, furniture, or walls of a room; that either directly or after remaining dormant for an unknown period of time, they may infect other persons; and that, by adopting suitable measures, they can be destroyed altogether, or rendered inoperative to a large extent. So far also these remarks have had special reference to the precautionary measures which form a part of personal and domestic hygiene, and which fall under the control and regulation of the private medical

attendant. The general proceedings which should be carried out under the advice of a health officer in places attacked or threatened by epidemic disease, are given in the following memorandum drawn up by Mr. Simon:—

"1. Wherever there is prevalence or threatening of cholera, smallpox, diphtheria, typhus, or any other epidemic disease, it is of more than common importance that the powers conferred by the Nuisance Removal Acts, and by various other laws for the protection of the public health, be vigorously but at the same time judiciously exercised by those in whom they are vested; and with regard to armies, that the instructions relative to the guidance of the medical officer in sanitary matters, contained in the army regulations, be duly carried out on the principle that the executive should act under authority, in order to carry out the required measures efficiently.

"2. If the danger be considerable, it will be expedient that the local authorities in civil life, and the commanding officers of armies, brigades, divisions, and regiments, in military life, avail themselves as soon as possible of the medical advice within their reach, in taking measures of prevention and protection against the spread of epidemic influences.

"3. Measures of precaution for prevention and protection are equally proper for all classes of society, civil and military. But it is chiefly with regard to the poorer civil population—therefore chiefly in the courts and alleys of towns, and at the labourers' cottages of country districts—that local authorities are called upon to exercise the utmost vigilance, and to proffer information and advice. Common lodging-houses, and houses

which are sublet in several small holdings, always require particular attention.

"4. Wherever there is accumulation, stink, or soakage of house-refuse, or of other decaying animal or vegetable matter, the nuisance should as promptly as possible be abated, and precaution should be taken not to let it recur. Especially all complaints which refer to sewers and drains, or to foul ditches and ponding of drainage, or to neglect of scavenging, should receive immediate attention. The trapping of house drains and sinks, and the state of cesspools and middens, should be carefully seen to. In slaughter-houses, and other places where beasts are kept, strict cleanliness should be enforced.

"5. In order to guard against the harm which sometimes arises from disturbing heaps of offensive matter, it is often necessary to combine the use of chemical disinfectants with such means as are taken for the removal of filth; and in cases where removal is for the time impossible or inexpedient, the filth should always be disinfected. Disinfection is likewise desirable for unpaved earth close to dwellings, if it be sodden with slops and filth. Generally, where cholera or typhoid fever is in a house or barrack, hospital or hut, the privies especially require to be disinfected.

"6. Sources of water-supply should be carefully and efficiently examined. Those of them which are in any way tainted by animal or vegetable refuse,—above all those into which there is any leakage or filtration from sewers, drains, cesspools, or foul ditches,—ought no longer to be drunk from. Where the disease is cholera, diarrhœa, or typhoid fever, it is especially essential that no foul water be drunk.

"7. The washing and lime-whiting of uncleanly premises (houses, huts, hospitals, barrack guard-rooms, and the like), especially of such as are densely or multifariously occupied, should be pressed with all practicable despatch.

"8. Overcrowding should be prevented. Especially where disease has begun, the sick-room should, as far as possible, be free from persons who are not of use or comfort to the patient.

"9. Ample ventilation should be enforced. Window frames should be seen to,—(1.) That they may be made to open, if not so made; and (2.) That they be kept sufficiently open. Especially where any kind of specific disease, communicable by infection of the air, has begun, it is essential, both for patients and for persons who are about them, that the sick-room and the sick-house or hospital be constantly and efficiently traversed by streams of fresh air. This is especially necessary at night, and steps should be taken to ensure efficient ventilation, even at some real or imaginary expense of comfort.

"10. The cleanest domestic habits should be enjoined. Refuse matters should never be suffered to remain or to linger within the dwelling, hospital, barrack-room, or hut. Such refuse must at once be removed, and at once disposed of, or cast into the receptacle provided for it. All things or utensils which have to be disinfected or cleansed should always be disinfected or cleansed without delay.

"11. With regard to material substances discharged or separated from the bodies of the sick, special precautions of cleanliness and disinfection are necessary. Among discharges or substances separated from the

body which it is proper to treat as capable of communicating disease, are those which come, in cases of small-pox, from the affected skin; in cases of cholera and typhoid fever, from the intestinal canal; in cases of diphtheria and scarlatina maligna, from the nose and throat, and the exhalations from the skin and the lungs saturating clothes; likewise, in cases of eruptive fevers, measles, scarlatina, rötheln, typhus, and the like, the general exhalations of the sick, and especially so of the convalescing, probably in connection with the desquamation of the skin. The caution which is necessary with regard to such matters must of course extend to whatever may be imbued with them; so that bedding, clothing, towels, and other articles which have been in use by the sick, do not become sources of mischief, either in the house to which they belong, or in houses to which they are conveyed. Moreover, in typhoid fever and cholera, the evacuations should be regarded as capable of communicating a similarly specific and infectious property to any night-soil with which they may be mingled in privies, drains, or cesspools. This danger of multiplying the sources of communicating disease must be guarded against by the chemical destruction, decomposition, or disinfection, of all the intestinal evacuations as soon as they are passed from the bowels, and certainly before they are thrown away, and so let loose upon the world. Above all, they must never be cast where they can run or soak into sources of drinking water.

"12. All reasonable care should be taken not to disseminate disease by the unnecessary association of persons suffering from the specific communicable diseases, either with healthy persons, or in wards of hospi-

tals where patients suffering with other diseases are being treated. This care is requisite not only with regard to the sick-house, ward, hospital, or ship, but likewise with regard to day schools, places of public resort, courts of justice, and other places where members of many different households are accustomed to meet.

"13. Where dangerous conditions of residence cannot be promptly remedied, it will be best that the inmates, while unattacked by disease, remove to some safer lodging. If disease begins in houses where the sick person cannot be rightly circumstanced and tended, medical advice ought to decide on the propriety or fitness of removing him to an infirmary or hospital. In extreme cases, special infirmaries may become necessary for the sick, or special houses of refuge for the endangered.

"14. The questions of quarantine ought to be decided by the circumstances of the special case, the preceding principles being kept in view.

"15. Privation, as predisposing to disease, may require special measures of relief.

"16. In certain cases special medical arrangements are necessary. For instance, as cholera in this country almost always begins somewhat gradually in the comparatively tractable form of what is called 'premonitory diarrhœa,' it is essential that, where cholera is epidemic, arrangements should be made for affording medical relief without delay to persons attacked even slightly with looseness of the bowels. So, again, where smallpox is the prevailing disease, it is essential that all unvaccinated persons (unless they previously have had smallpox) should very promptly be vaccinated; and re-vaccination should also be offered, both to persons

above puberty who have not been vaccinated since childhood, and to younger persons whose marks of vaccination are unsatisfactory.

"17. It is always to be desired that the people should, as far as possible, know what real precautions they can take against the disease which threatens them, what vigilance is needful with regard to its early symptoms, and what, if any, special arrangements have been made for giving medical assistance within the district. Especially in the case of smallpox or of cholera such information ought to be spread abroad by means of printed bills or placards. In any case where danger is great, house-to-house visitation, or personal inspection of all by discreet and competent persons, may be of the utmost service, both in quieting unreasonable alarm, and in leading or assisting the less educated and the destitute parts of the population to do what is needful for safety.

"18. These memoranda relate to occasions of emergency. The measures suggested must be regarded as of an extemporaneous kind. Permanent provisions for securing public health have not been in express terms insisted on. In proportion as a district or number of individuals, such as an army or regiment, is habitually well cared for by its sanitary authorities, the more formidable emergencies of epidemic disease are not likely to arise."

Section II.—Disinfectants.

In the wide sense of the word, the term disinfectant may be defined as any agent which oxidises or renders innocuous decomposing organic matters and offensive

gases, which arrests decomposition, or which prevents the spread of infectious diseases by destroying their specific contagia. The term, therefore, includes any agent which possesses deodorising, antiseptic, or fixative properties.

Without entering into any discussion on the *modus operandi* of disinfectants generally (because the subject is still under dispute), it will be convenient for practical purposes to enumerate and describe the most useful amongst them *seriatim* and without any attempt at classification

1. *Heat and Cold.*—While extreme cold prevents putrefactive change, and therefore acts as an antiseptic, extreme heat is destructive of all organic matter, and in this respect it is the most efficacious, as it is the most ancient, of all disinfectants. But even a temperature much below that of actual combustion is found to be sufficiently powerful, if continued for any length of time, to kill animal or vegetable germs, and to render inert any contagious matter. Thus, the late Dr Henry proved experimentally that the vaccine virus was deprived of the power of reproduction when exposed for three hours to a temperature of 140° Fahr., while a temperature of 120° failed to produce this effect. As a result of these and other experiments, he was the first to recommend the employment of the hot-air chamber to disinfect clothing, bedding, and the like; and experience has proved that, when conducted with care, the plan is highly successful.

2. *Charcoal*, and specially animal charcoal, is a powerful deodorant, but there is no evidence to show that it has any effect in destroying specific disease-germs. It oxidises offensive organic effluvia, and is

therefore very useful in purifying sewer-gases or other filth-emanations.

3. *Chlorine* decomposes sulphuretted hydrogen and ammonium sulphide more certainly than any other gas, and is an energetic destroyer of all organic substances prone to decay. It is especially valuable in purifying rooms which have been occupied by persons suffering from infectious diseases, but it is doubtful whether it can be of much service in the hygiene of the sick-room itself, because, even when largely diluted, it is very irritating to the lungs. It is given off in small quantities by chloride of lime moistened with water, or when employed in scrubbing out the floor. It may also be obtained by adding a little muriatic acid gradually to a wine-glassful of Condy's fluid, or to crystals of potassium chlorate. When required in large quantity for the disinfection of empty rooms, it is most rapidly obtained in one of the following ways:—(1.) To equal parts of common salt and binoxide of manganese add two parts of water, and about the same amount of strong sulphuric acid. (2.) To one part of powdered binoxide of manganese add four parts by weight of strong muriatic acid. (3.) To three parts of bleaching powder add one part of strong sulphuric acid. In any case, the quantities required will depend upon the size of the room.

4. *Nitrous Acid.*—Nitrous fumes are obtained by adding strong nitric acid, diluted with a little water, to copper filings. The power of oxidation of organic matter possessed by nitrous acid is very great, and no disinfectant will more readily remove the offensive smell of the dead-house. The fumes, however, are exceedingly irritating and dangerous,—so much so, that this process

of disinfection is only suitable for empty rooms, and under skilled superintendence.

5. *Iodine*, though less useful than chlorine, has been recommended as a substitute by Dr. Richardson and others. It is a powerful antiseptic, and may be diffused through the air of a room by placing a small quantity of the substance on a warm plate, but it is not suited for the sick-room.

6. *Bromine*.—The vapour of bromine can be obtained by exposing a solution of bromine in potassium bromide in open dishes. It was largely used as an atmospheric disinfectant during the American War, but has not found much favour in this country.

7. *Sulphur Dioxide* or *Sulphurous Acid Gas*.—This is exceedingly useful for disinfecting empty rooms. It is obtained by burning sulphur in an earthenware pipkin or other vessel that will not readily crack. It decomposes sulphuretted hydrogen, and as it combines with ammonia, it deodorises or destroys stinking alkaloids, and, probably, disease-germs. Usually fumigation is best effected by burning about 1 lb. of lumps of sulphur for every thousand cubic feet of space in an iron dish (or the lid of an iron saucepan) supported on a pair of tongs over a bucket of water. In a long room it is advisable to burn the sulphur in one or two places in order to secure thorough disinfection.

8. *Carbolic Acid*.—This is one of the most popular disinfectants, and is especially valuable on account of its highly antiseptic properties. In its pure state it is a white crystalline solid, which in a diluted form has been found to be of immense service in preventing putrefactive change in surgical wounds. The commercial article is a thin, tarry fluid, possessing a somewhat

offensive odour. It is highly poisonous, and has already been productive of several fatal accidents, on account of its having been mistaken for porter or other fluids. For this reason the carbolic acid powder is safer as a domestic disinfectant. It can be employed in scrubbing out floors, in steeping infected clothing, and in vessels for receiving the excreta. It is also very useful in disinfecting urinals, latrines, water-closets, stables, midden-heaps, etc. In whatever form, the acid is destructive of the low forms of animal and vegetable life, and arrests or prevents all kinds of putrefactive change. It should never be sprinkled freely about the sick-room, on account of its irritating and disagreeable odour.

9. *Terebene.*—This disinfectant, which has recently been designed by Dr. Bond of Gloucester, is obtained from spirits of turpentine. It has a fragrant odour, very much resembling that of pinewood, and is powerfully antiseptic. It has been used by Professor Maclean at the Royal Victoria Hospital, Netley, with excellent effects, in correcting the highly offensive evacuations of dysentery, and the fœtor of purulent collections, such as occur in cases of liver abscess and empyema, while, at the same time, it was found to sweeten the air of the wards by diffusing through them its own peculiar pine-like fragrance. It is especially suited as a deodorant for water-closets and commodes, and as a disinfectant for the bowel-discharges of infectious diseases. It is only slightly soluble in water, but it mixes readily with sweet oil or with benzoline for use in surgical dressings. The experience of its effects gained at Netley shows that it is peculiarly suitable for use in Indian hospitals and in hospitals generally, and it specially commends itself for use in the sick-room.

10. *Cupralum* or *Terebene Powder*, also designed by Dr. Bond, is a combination of terebene with cupric sulphate and potassic bichromate, and possesses the same agreeable odour. It neutralises ammonia and sulphuretted hydrogen, and acts as a powerful coagulator of albumen. It is specially adapted for disinfecting bowel-discharges, water-closets, urinals, and drains.

11. *Condy's Fluid*, red and green, consists of a solution of potassium permanganate. It is essentially an oxidising agent, and as it is odourless it is a very valuable disinfectant in the sick-room.

12. *Chloride of Aluminium*, or "*Chloralum*," is a powerful disinfectant, and possesses the great advantages of being non-poisonous, inodorous, and very cheap. Professor Wanklyn says that "for removing fœtor and effluvia, it is better and more available than any agent with which I am acquainted. In this respect it is incomparably superior to chloride of lime." Dr. Dougall, after a series of carefully-conducted experiments, likewise maintains that it arrests putrefactive change, and prevents the appearance of animalculæ to a greater extent than any of the commonly employed disinfectants. Not being volatile, it cannot be regarded as an aerial disinfectant, but it is exceedingly useful in washing infected clothing, or as a scouring material for cleansing rooms. It is also an excellent sewage deodorant.

13. *Chloride of Lime* is useful, as already stated, in supplying chlorine gas and for disinfecting drains and fæcal matters.

14. *M'Dougall's powder* consists of carbonate of lime and magnesium sulphite. Like Calvert's carbolic acid powder, it may be employed very advantageously for

cleansing purposes, and for the disinfection of masses of putrescent matter, sewage, or excreta.

15. *Sulphate of Copper* has been recommended by Dr. Dougall as possessing antiseptic properties equal to those of chloralum; but it is not so suitable, on account of its price and poisonous nature.

16. *Chloride of Zinc.*—"Burnett's solution" consists of 25 grains of this salt to every fluid drachm. It destroys ammoniacal compounds and organic matter. When used, it should be diluted with eight times its bulk of water.

17. *Ferrous Sulphate* or *Green Copperas* has been largely used for disinfecting heaps of manure and sewage. It has also been recommended by Pettenkofer to be added to cholera evacuations for the purpose of destroying the contagium; but it does not appear to have been attended with any good results.

Other sewage disinfectants have already been described in the chapter on the Purification of Sewage.

18. *Cooper's Salts*, which consist of a compound of sodium, calcium, and magnesium chlorides, have also been recommended as street and sewer disinfectants.

19. *Potassium Bichromate* has been extolled by Dr Angus Smith, and chromic acid by Dr. Dougall, as being powerful antiseptics, but it is doubtful whether their price will ever permit of their being largely employed.

Although the names of other agents could be added to this list, it embraces all the more useful disinfectants, and several which, while they are useful, are not so common. Probably the most reliable amongst them may be enumerated as follows:—heat, sulphurous acid, carbolic acid, Condy's fluid, chloralum, ferrous sulphate, chloride of zinc, chloride of lime, M'Dougall's and Calvert's powders, terebene, cupralum, and charcoal.

The following summary of results in careful experimentation with regard to four of these disinfectants is quoted from Dr. Baxter's admirable paper in Mr. Simon's *Reports*, New Series, No. VI., and it is quoted here as a guide to future experimentation in the same direction :—

"1. Evidence has been adduced to show that carbolic acid, sulphur dioxide, potassic permanganate, and chlorine, are all of them endowed with true disinfectant properties, though in very various degrees.

"2. It is essential to bear in mind that antiseptic is not synonymous with disinfectant power, though, as regards the four agents enumerated above, the one is, in a certain limited sense, commensurate with the other.

"3. The effectual disinfectant operation of chlorine and potassic permanganate appears to depend far more on the nature of the medium through which the particles of infective matter are distributed, than on the specific character of the particles themselves.

"4. When either of these agents is used to disinfect a virulent liquid containing much organic matter, or any compounds capable of uniting with chlorine, or of decomposing the permanganate, there is no security for the effectual fulfilment of disinfection short of the presence of free chlorine or undecomposed permanganate in the liquid after all chemical action has had time to subside.

"5. A virulent liquid cannot be regarded as certainly and completely disinfected by sulphur dioxide unless it has been rendered permanently and strongly acid. The greater solubility of this agent renders it preferable, *cæteris paribus*, to chlorine and carbolic acid, for the disinfection of liquid media.

"6. No virulent liquid can be considered disinfected by carbolic acid unless it contain at least 2 per cent by weight of the pure acid.

"7. When disinfectants are mixed with a liquid, it is important to be sure that they are thoroughly incorporated with it; and that no solid matters capable of shielding contagium from immediate contact with its destroyer be overlooked.

"8. Aerial disinfection, as commonly practised in the sick-room, is either useless or positively objectionable, owing to the false sense of security it is calculated to produce. To make the air of a room smell strongly of carbolic acid by scattering carbolic powder about the floor, or of chlorine, by placing a tray of chloride of lime in a corner, is, so far as the destruction of specific contagia is concerned, an utterly futile proceeding

"9. When aerial disinfection is resorted to, the probability that the virulent particles are shielded by an envelope of dried albuminous matter, should always be held before the mind. Chlorine and sulphur dioxide are, both of them, suitable agents for the purpose; the latter seems decidedly to be the more effectual of the two. The use of carbolic vapour should be abandoned, owing to the relative feebleness and uncertainty of its action. Whether chlorine or sulphur dioxide be chosen, it is desirable that the space to be disinfected should be kept saturated with the gas for a certain time, not less than an hour; and this in the absence of such gaseous compounds as might combine with or decompose the disinfectant, and so far impair its energy.

"10. When the thorough disinfection of a mass of solid or liquid matter, through which a contagium is disseminated, is impracticable, we should guard against

giving a false security by the inadequate employment of artificial means. It is probable that all contagia disappear sooner or later under the influence of air and moisture, and that the absence of these influences may act as a preservative. When, therefore, we cannot advantageously or effectually supersede the natural process of decay, we must be sure that we do not hamper it by the injudicious use of antiseptics.

"11. Dry heat, when it can be applied, is probably the most efficient of all disinfectants. But, in the first place, we must be sure that the desired temperature is actually reached by every particle of matter included in the heated space; secondly, length of exposure and degree of heat should be regarded as mutually compensatory factors, within certain limits."

"The above statements are not so discouraging as they may appear at the first glance to our reliance upon artificial disinfection. If we believe that all contagia are generated, like those of small-pox and scarlet fever, in the infected organism, and there only, the out-look is a hopeful one. We might even anticipate an approach to the *perfect* fulfilment of the work of disinfection, by subjecting all matters, immediately after their removal from the affected person, and before any dilution or admixture, to the full influence of one or other among the destructive agencies at our command. On the other hand, if the contagium of any disease is capable of being generated *de novo* outside the body (pythogenic origin of enteric fever, typhus created by overcrowding) such contagium can hardly be eradicated by any method of artificial disinfection. For cases of the latter kind, the opening words of the memorandum previously referred to, furnish the only solution. 'It is

to cleanliness, ventilation, and drainage, and the use of perfectly pure drinking-water, that populations ought mainly to look for safety against nuisance and infection. Artificial disinfectants cannot properly supply the place of these essentials; for, except in a small and peculiar class of cases, they are of temporary and imperfect usefulness.' "

Section III.—Practical Disinfection.

1. *Hygiene of the Sick-room.*—In all cases of highly infectious disease, if the patient is not removed to a hospital, the first duty to be attended to is the enforcement of a strict domestic quarantine by isolation of the patient whenever it is possible; the next point is to make certain that the room is well lighted and sufficiently ventilated by means of open windows, and fires if necessary; and the third point is to require the instant removal of all extraneous furniture, such as carpets, curtains, and the like. The attendant on the patient should receive strict and precise injunctions, not only with regard to the nursing of the patient, but also with regard to the maintenance of the utmost cleanliness in the room; the disinfection of excreta, slops, soiled linen, etc., and their immediate removal afterwards; and other points of detail depending upon the special nature of the disease and the circumstances of the patient.

Although aerial disinfectants may be regarded as of doubtful efficacy in the sick-room, they are deemed to be useful or expedient by many; and, when properly selected and managed, it may be said, at all events, that they do not do any harm, if they are not productive of

much good. The great danger is, that when employed without due precaution, they may only serve to disguise the signs of insufficient ventilation, and in this way conduce to inattention as regards this most essential point. If they are employed, they should not be irritating to the patient. Chlorine gas slowly evolved, or carbolic acid vapour, either given off from powder freely sprinkled about the room or by a spray-producer, have been strongly recommended by many, but as they are of doubtful efficacy and are often the source of much discomfort if not of occasional injury, they should be used with caution. On account of its agreeable aroma, as well as its deodorant and disinfecting properties, terebene is specially adapted for use in the sick-room when an aerial disinfectant is deemed necessary. Hanging rags steeped in disinfectant solutions about the room is not to be commended, but a sheet moistened with a strong solution of chloralum, cupralum, or Condy's fluid, and suspended outside the door of the room, is very necessary to complete the isolation of the patient. The infected clothing, etc., should be received into a tub containing chloralum or carbolic acid, and the ejecta, etc., should be instantly covered with terebene or a solution of green copperas, chloralum, cupralum, or carbolic acid. Care must also be taken, in using different disinfectants, that they do not counteract each other; for example, carbolic acid decomposes Condy's fluid. Further, the inunction of the body of the patient, in certain of the exanthematous infectious diseases, and especially scarlet fever, with camphorated oil, or a mixture of terebene and sweet oil, or a weak solution of glycerine and carbolic acid, followed by disinfecting baths during convalescence, is attended with the best results.

2. *Disinfection of Empty Rooms and Uninhabited Places.*—After a case of infectious disease, the room should be thoroughly cleansed and disinfected. The furniture should be washed with a strong solution of chloralum (three or four ounces to the gallon of water), or with carbolic acid or terebene soap, and the room, as far as possible, emptied. Afterwards the floor and wood-work should also be thoroughly washed with carbolic acid soap, and the paper should be removed. Then, after closing doors, windows, and other openings, chlorine, sulphurous acid, or nitrous acid gas, should be generated in large quantities in the manner already described, and the room kept closed for several hours. After this, the door and windows should be thrown open, and in a few days the ceiling should be washed with quick lime and whitened, and the walls re-papered.

3. *Disinfection of Clothing, Bedding, etc.*—Any material of this description which cannot be injured by being washed, should be steeped in a solution of chloralum or carbolic acid, and boiled. If Condy's fluid be used, the material should merely be immersed, and afterwards rinsed out in cold water, otherwise the solution will stain. In all cases, however, when it can be carried out, the clothing, bedding, etc., are best disinfected by being exposed for an hour at least to a dry heat of about 240° or 250° Fahr., and for this purpose every town of any dimensions should be provided with a hot-air disinfecting chamber for public use. Such a chamber is built of brick, and is heated by a coil of hot-air pipes lying underneath a perforated grating, and communicating with a furnace which opens outside. The one in use in Dublin cost £400. Dr. Ransome of Nottingham has devised a specially constructed disin-

fecting chamber, which, while it secures a sufficiency of heat, prevents the articles from being scorched. In connection with every such chamber in large towns there should be a covered van or hand-cart for conveying infected articles, and great care should be taken, by the free use of disinfectants or by wrapping the articles in a sheet moistened with a strong disinfecting solution, to prevent any risk of spreading disease. A small portable disinfecting chamber is much needed for rural districts.

The hair of infected mattresses should be teased out, fumigated, and exposed to the air, if the mattresses cannot be disinfected in a hot-air chamber. Rags and other articles which can be spared should be destroyed by fire, but so as not to create nuisance. When clothing cannot be disinfected by heat, Dr. Ransome has proposed that the different articles should be placed, layer on layer, in a box, with hot sand or bricks placed at the bottom, and sprinkled over with carbolic acid.

4. *Disinfection of Water-Closets, Urinals, Sinks, etc.*—In any district where an epidemic prevails or is threatening, disinfection of all water-closets, etc., should be carried on systematically, either with solutions of chloralum, cupralum, carbolic acid, copperas, or Burnett's fluid. Cooper's salts might be used for the streets, lanes, and open courts. Any manure heaps or other accumulations of filth, which it is inexpedient to disturb or impossible to remove, should be covered with powdered vegetable charcoal to the depth of two or three inches, or with a layer of fresh dry earth, or with freshly-burnt lime, if charcoal cannot be obtained. Cess-pits and midden-heaps may be disinfected with solutions of copperas (3 lbs. to the gallon of water),

or with cupralum or chloralum (1 lb. to the gallon of water). It need hardly be said, however, that in a town or district well looked after by the sanitary authorities, no such filth-accumulations would be allowed to take place at any time.

5. *Disinfection of the Dead Body.*—When a patient dies of a highly infectious disease, such as small-pox or scarlatina maligna, the body should be washed with a very strong solution of carbolic acid or chloralum, or, better still, enveloped in a sheet saturated with such solution, and placed in the coffin as soon as possible, disinfectants being again freely used, and the lid screwed down. The burial should take place without delay; or in crowded districts, and in towns where a mortuary is provided, the dead body should be at once removed thither. The linen worn by the patient at death, if not buried with the body, should be destroyed by fire; but when this cannot be done without creating nuisance, the burning should be effected at some distance from houses, or the bedding may be saturated with quicklime, and buried.

It may be urged that many of these directions are needlessly minute, and that, in fact, they cannot possibly be carried out in perhaps the great majority of cases. In answer to such objections, let it be said, once and for all, that no labour is wasted which aims at preventing the spread of disease, even though it be often attended with failure; and that, however limited be the means or opportunity of carrying out preventive or precautionary measures, such means and such opportunity should always be used, so as to be productive of the best possible results under the circumstances. Although a number of disinfectants have been mentioned, it is

always advisable that only a few, and those deemed the most efficient, should be used. Thus, for use in the sick-room terebene appears to be one of the most suitable for steeping clothing, a solution of carbolic acid; for disinfecting drains, closets, etc., cupralum or carbolic acid powder; and for fumigation, sulphurous acid gas. For more special directions, see Appendix.

CHAPTER XV.

THE DUTIES OF MEDICAL OFFICERS OF HEALTH.

By clauses 189 and 190 of the Public Health Act 1875, it is enacted that it shall be the duty of every urban and of every rural sanitary authority, throughout England and Wales, to appoint from time to time a legally qualified medical officer or officers of health for the efficient execution of the purposes of the Sanitary Acts. In the case of rural sanitary districts, such officers may be the district medical officers of unions, who are to a certain extent under the control of the Local Government Board; but in the case of urban sanitary districts, those medical officers of health are alone subject to the control of the Local Government Board whose salaries are partly paid out of monies voted by Parliament. Such sanitary authorities, therefore, who do not choose to receive assistance from the public purse in the payment of their health officers, may appoint or dismiss such officers without the consent of the Local Government Board, and may issue such regulations for their guidance as they may from time to time determine. In either case, however, the duties of the medical officer of health will, in great measure, be identical as regards the main points; and hence the following regulations, which have been issued by the Local Government Board for the guidance of medical

officers of health whose appointments are made subject to the approval of the Board, may be considered as more or less applicable to all health officers. By an order, dated 11th November 1872, which is still in force, these duties are thus defined:—

"The following shall be the duties of the medical officer of health in respect of the district for which he is appointed; or, if he shall be appointed for more than one district, then in respect of each of such districts:—

"1. He shall inform himself, as far as practicable, respecting all influences affecting or threatening to affect injuriously the public health within the district.

"2. He shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

"3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

"4. He shall be prepared to advise the sanitary authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the sanitary authority or authorities; and in cases requiring it, he shall certify, for the guidance of the sanitary authority or of the justices, as to any matter in respect of which the certificate of a medical officer of health or a medical practitioner is required as the basis or in aid of sanitary action.

"5. He shall advise the sanitary authority on any question relating to health involved in the framing and subsequent working of such bye-laws and regulations as they may have power to make.

"6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease of a dangerous character within the district, he shall visit the spot without delay and inquire into the causes and circumstances of such outbreak, and advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and, so far as he may be lawfully authorised, assist in the execution of the same.

"7. On receiving information from the inspector of nuisances, that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps authorised by the statutes in that behalf as the circumstances of the case may justify and require.

"8. In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the sanitary authority, he shall himself inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, exposed for sale, or deposited for the purpose of sale, or of preparation for sale, and intended for the food of man, which is deemed to be diseased, or unsound, or unwholesome, or unfit for the food of man; and if he find that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be seized, taken, and carried away in order to be dealt with by a justice according to the provisions of the statutes applicable to the case.

"9. He shall perform all the duties imposed upon him by any bye-laws and regulations of the sanitary authority, duly confirmed, in respect of any matter affecting the public health, and touching which they are authorised to frame bye-laws and regulations.

"10. He shall inquire into any offensive process of trade carried on within the district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

"11. He shall attend at the office of the sanitary authority or at some other appointed place, at such stated times as they may direct.

"12. He shall from time to time report, in writing, to the sanitary authority, his proceedings and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been enabled to ascertain the same.

"13. He shall keep a book or books, to be provided by the sanitary authority, in which he shall make an entry of his visits, and notes of his observations and instructions thereon, and also the date and nature of applications made to him, the date and result of the action taken thereon, and of any action taken on

previous reports, and shall produce such book or books, whenever required, to the sanitary authority.

"14. He shall also prepare an annual report, to be made at the end of December in each year, comprising tabular statements of the sickness and mortality within the district, classified according to diseases, ages, and localities, and a summary of the action taken during the year for the preventing the spread of disease. The report shall also contain an account of the proceedings in which he has taken part or advised under the Sanitary Acts, so far as such proceedings relate to conditions dangerous or injurious to health, and also on account of the supervision exercised by him, or on his advice, for sanitary purposes, over places and houses that the sanitary authority has power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same during the year. It shall also record the action taken by him, or on his advice, during the year, in regard to offensive trades, bakehouses, and workshops.

"15. He shall give immediate information to the Local Government Board of any outbreak of dangerous epidemic disease within the district, and shall transmit to the Board, on forms to be provided by them, a quarterly return of the sickness and deaths within the district, and also a copy of each annual and of any special report.

"16. In matters not specifically provided for in this order, he shall observe and execute the instructions of the Local Government Board on the duties of Medical Officers of Health, and all the lawful orders and directions of the sanitary authority applicable to his office.

"17. Whenever the Diseases Prevention Act of 1855 is in force within the district, he shall observe the directions and regulations issued under that Act by the Local Government Board, so far as the same relate to or concern his office."

For the efficient and conscientious discharge of these duties, it is evident that a medical officer of health must make himself thoroughly acquainted with the fundamental principles of public and practical hygiene, with the general and local circumstances which may affect the health of the population in his district, and

with the various clauses of the Public Health and other Acts which more immediately concern his office. So much is left to his discretionary power in advising the Sanitary Authority, and in certifying as to what is or is not injurious to the public health, that he cannot but feel the grave responsibility which will devolve upon him, if through ignorance or neglect on the one hand, or through mistaken zeal and want of tact on the other, he fails to carry out his duties honestly, judiciously, and efficiently.

As there is no doubt that considerable difficulty will be experienced at the outset by most health officers in regard to the mode in which their duties should be carried out, the various suggestions and practical details summarised under the following sections, may, it is hoped, prove as serviceable as they are reliable :—

SECTION I.—NATURAL CONDITIONS AFFECTING THE HEALTH OF THE POPULATION CONTAINED IN THE DISTRICT.

These comprise the geological and topographical characteristics of the district, the water-supply, and the climate.

1. *Geological Conditions.*—Official information as regards these may be obtained from the Ordnance maps and the special sections published by the Surveyor-General; while fuller details could be readily collected from local sources. In most districts there will generally be found some one who has made the geology of the locality a special study.

2. *Topographical Conditions.*—These relate to the

situation of the various parts of the town or district, whether low-lying, elevated, or sloping.

3. *Water-supply.*—The quantity and quality of the obtainable water-supply in a district will depend very much on the two previous sets of conditions. So also will the nature of the subsoil and the facilities for drainage and sewerage. All this, however, has been fully explained in previous parts of this work. (See Chapters VI., VIII., and XIII.)

Speaking generally, the diseases which are found to be most largely associated with natural conditions in this country are phthisis, and probably also other lung diseases, ague, cancer, rheumatism, heart-disease, and goître. In this field of inquiry, Mr. Haviland's writings on the geographical distribution of disease will be found to be very serviceable.

4. *Climate.*—Under this heading are comprised the meteorological conditions of the district, such as the daily temperature and rainfall, the force and direction of winds, the barometric pressure, the degree of humidity, and the amount of ozone. In most large towns these observations are already being carefully recorded, and where this is the case, the health officer should endeavour to obtain, through the sanitary authority, the record of the observations weekly. In districts where no such observations are made, it will be no part of his duty to supply this information, but at the same time it is necessary that he should take cognisance of meteorological fluctuations, because they constitute very important factors of health or disease in every district. With regard to the instruments required and the systematic way in which these observations should be made, the short chapter on meteorology in Dr. Parkes'

Manual of Practical Hygiene, or Buchan's *Handbook of Meteorology*, will give all the needful information.

SECTION II.—ARTIFICIAL CONDITIONS AFFECTING THE HEALTH OF THE POPULATION CONTAINED IN THE DISTRICT; such as—

1. *Habitations of the People.*—So far as possible the sanitary condition of every house in the district should be inquired into. Of course the health officer himself could not undertake such a laborious inquiry, but it could be easily and efficiently carried out by the temporary appointment of one or more competent persons, who would be paid by the sanitary authority and directed by the health officer; while in small urban or rural districts it can be carried out by the sanitary inspector. With regard to this part of the subject, the remarks of Mr. Dyke, the accomplished health officer of Merthyr Tydfil, are well worth quoting:—"Such an inquiry was made in Merthyr in the autumn of 1866; nearly 10,000 houses were examined and reported on by four intelligent persons; five weeks were occupied in the examination and report, the cost to the local board being £25. This inquiry embraced the following:— The name of the street, number of each house, names of occupier and owner, number of family and lodgers: the ventilation, how it was secured, whether by back doors, or by windows whose upper sashes could be fully let down; the number of privies or of water-closets, and the state of these; the water-supply, whence derived, and the state of any back premises, noticing particularly whether any animals or poultry were kept. When these returns were completed they

were tabulated by the medical officer, for *each street* in *each district*, and the results summed up. The usefulness of these returns has been continuous. They now afford standpoints of reference whence to mark the improvements made, and to note the dark spots that call for amendment; by referring to this 'Dictionary of Habitations,' the state of each house is at once apparent, and upon the occurrence therein of any case of disease, such as, *e.g.*, enteric fever or phthisis, the exciting cause, whether excrementitious exhalations or dampness of foundations, may be found." (*Brit. Med. Journal*, November 16, 1872.)

In carrying out a systematic inquiry of this description in rural districts, it is advisable that the inspector should complete the survey of one or more parishes or villages before submitting the details to the medical officer of health, who would then appoint a day for going over the survey with the inspector. During the inspection he should satisfy himself as to the accuracy of the returns, advise with regard to particular defects, and in this way make himself fully acquainted with the sanitary condition of every part of his district in detail. The tabulated forms to be used for such a survey, when it is authorised by the sanitary authority, will vary slightly according as the district is urban or rural. Those devised by Dr. Bond of Gloucester, although somewhat bulky, will be found to be well arranged and admirably suited for rural districts. They are published by Mr. Headland, 2 Westgate Street, Gloucester, and contain the following headings in the several columns:—Number; No. of case in nuisance book; date of inspection; situation and description of premises; names of occupier and

owner; number of living rooms, sleeping rooms, and inmates; nature, situation, and condition of closet-accommodation; nature of water-supply; defects in drainage, ventilation, or general condition of premises; existence of any special source of actual or possible nuisance; remarks by medical officer of health; additional observations. With very rare exceptions, the inspector will meet with no opposition in carrying out the survey, nor the medical officer of health in obtaining any information with regard to any points which he may consider desirable. Further particulars with regard to the sanitary condition of premises, overcrowding, nuisances generally, and how to draw up reports, will be given in Section IV. (See also Chapter IX.)

2. *Water-Supply.*—In districts where the water-supply is public, the medical officer of health should make himself acquainted with the quality of the water, amount per head, and the risks of pollution, both as regards the source of supply and the mode of distribution. The nature of the supply, whether constant or intermittent, the relation between mains and closets; the situation and condition of cisterns; the separation of cisterns for domestic supply from those supplying closets; the situation of overflow-pipes, and the like, are all points which should receive careful attention. In rural districts, the sufficiency of the water-supply, as well as its quality, the situation of wells, and the risks of pollution, should all be duly noted, and samples of suspicious well-water should be examined. In villages where the water-supply is insufficient, it will become a question for the medical officer of health to advise generally as to how this want may best be

remedied, whether by providing one or more public wells, by introducing a public supply, by storage of the rainfall, or by carting water into the village to meet special emergencies, leaving of course all practical details to be dealt with by the sanitary engineer or inspector. (See Chapters VI. and VII.)

3. *Drainage, Sewerage, Scavenging, etc.*—In towns full information with regard to these conditions will be obtained from the borough engineer or town surveyor. Special attention should be given to the ventilation and flushing of sewers, and the condition of house-drains as regards ventilation, flushing, freedom from smell, and efficient trapping; while the ventilation of water-closets, soil-pipes, and as far as possible the severance of all direct communication of house-drains with sewers, are additional points of importance which should not escape notice. The efficiency of the scavenging arrangements should also be carefully inquired into. In country districts it will devolve upon the medical officer of health to report as to whether the drainage of particular villages is satisfactory, and to recommend or not, as he may think fit, as to whether a competent engineer should be called in to survey and prepare plans. In certain cases, too, he will have to inquire and decide as to whether public scavenging has not become necessary to ensure adequate local cleanliness. (See Chapters XI., XII., and XIII.)

4. *Factories, Workshops, Bakehouses, Public Institutions, Slaughter-houses, etc.*—These should be examined with reference to overcrowding, air-impurities, and the production of nuisances generally. (See Chapter III. and Section IV. of the present chapter.) Factories

already under Government inspection would not of course be subject to the supervision of the health officer, except in so far as they prove to be a nuisance or injurious to the health of the neighbouring inhabitants. In country districts special attention should be given to the sanitary condition of village-schools, whether public or private, and also to the sanitary condition of graveyards.

SECTION III.—VITAL STATISTICS.

In addition to obtaining a full knowledge of the natural and artificial conditions which affect the health of the population, the medical officer of health should also make himself acquainted with the vital statistics of his district. By referring to the more recent Quarterly and Annual Reports of the Registrar-General, the books of the district registrar, the abstracts of the Boards of Guardians, and any reports which have already appeared with regard to the health of the district, he will obtain all the statistical data representing its vital history for the past few years, as indicated by the number of the population, its rate of increase, the birth-rate, the marriage-rate, the rate of mortality, the prevalency of epidemic or other specially fatal diseases, the death-rate at different ages, the amount of pauperism, etc. From the last census returns, again, he will obtain much useful information as regards the areas, houses, and population, and the ages, civil condition, and occupation of the people.

Amongst other works which will be found very serviceable, are the Digest of the English Census of 1871, by Mr. Lewis, and the Supplement to the Thirty-

fifth Annual Report of the Registrar-General, published in 1875. This supplement contains Dr. Farr's Report on the Mortality of the Registration Districts of England during the years 1861-1870, a report which is full of information of the most varied kind, and exhibits in the most masterly way the wide range of logical deductions that can be based on vital statistics when properly tabulated and accurately arranged.

Such a retrospect, it need hardly be said, would form a sound basis of local statistical knowledge to start with, and by pursuing the same course with regard to the registration and pauper returns, which should be obtained regularly, the medical officer of health will be in a position at all times to inform the sanitary authority concerning the prevalence of infectious and preventable diseases, and advise as to what steps should be taken. But as the death-rate gives no sufficient indication of the sick-rate, he should also obtain the pauper sick returns immediately after each meeting of the guardians, and as far as possible the returns from the public medical institutions in his district. Arrangements should likewise be made through the sanitary authority, that poor-law medical officers should report without delay the occurrence of any case of fever or infectious disease, and that the district registrar should at once forward a return of any death from such disease. Further, if the medical officer of health is precluded from practice, he will generally find that the medical practitioners in his district will give him much timely information, provided he is careful not to make himself too officious; but until the registration of cases of infectious disease is rendered compulsory on householders, the only returns

which are provided for in the instructions of the Local Government Board are the returns of the district registrar, the pauper sick returns, and such returns with regard to infectious disease which the sanitary inspector can obtain.

The district registrars throughout the country are instructed by the Registrar-General to forward the returns of births and deaths to the medical officer of health, and are allowed 2d. per entry for remuneration, which the sanitary authority is empowered by the Local Government to pay. The sanitary authority also supplies the blank forms, and defrays the expense of postage. Except as regards deaths from fever or other infectious disease, a return of which should be forwarded immediately, the usual returns of the registrar should be forwarded to the medical officer of health at the close of every week. Blank forms may be obtained from Messrs. Knight and Co., publishers, Fleet Street, London; Messrs. Shaw and Sons, Fetter Lane, London; or Messrs. Farrant and Frost, Merthyr-Tydfil. (See Appendix.)

By means of the information supplied by these weekly returns, the medical officer of health is enabled to tabulate the mortality statistics in such a manner as will show the birth-rate, the total death-rate, the death-rate at different ages, the death-rate from zymotic disease, the connection between the total infantile or zymotic death-rate and the sanitary or insanitary condition of various parts of his district, the prevalency of any particular diseases in certain areas, and so on. If the district is a large urban one, the diseases may be classified according to sub-districts or streets, and if it be a large rural one, they may be

classified according to sub-districts or parishes. In large urban districts the classification should be that used by the Registrar-General, or the system recommended by the Society of Medical Officers of Health. (See Appendix.) In small urban or rural districts, however, it is by no means necessary to compile elaborate tables, and the classification which is given in the quarterly returns to the Local Government Board, or some similar classification, will answer all practical purposes. For the sake of comparison it is much to be regretted that some uniform system of classification is not enforced in all districts, a simple system for rural and small urban districts, and a more elaborate system for urban districts containing say 25,000 inhabitants and upwards. In combined districts too, there is some chance of confusion arising from the fact that the registration sub-districts are frequently not conterminous with the several sanitary districts, inasmuch as small urban districts generally form part of a registration sub-district, the other part being included in a neighbouring rural sanitary district.

The first question, then, for the medical officer of health to decide, is the system of classification which he may consider it most expedient to adopt; and having decided this it becomes a simple matter to tabulate the returns week by week, and summarise them monthly or quarterly as the case may be. If monthly reports are submitted, it is the practice in large urban districts to take five weeks for the months of March, June, September, and December, and four for the other months, but in small districts the deaths may be conveniently registered according to the date of death, and not according to the several weeks in

which they may happen to be registered. The only objection to this course is the fact that under the present system of registration it sometimes happens that a death does not appear in the registrar's returns until several weeks after it has occurred, and it is therefore customary to enumerate the deaths *registered* from week to week irrespective of the date of death.

After carefully tabulating and correcting the totals of deaths according to sex, age, locality, disease, etc., it often happens that some further corrections must be made for deaths not belonging to the district, which occur in large institutions, such as hospitals, workhouses, and lunatic asylums. Take for example the case of a town of some 10,000 inhabitants in the centre of a union of some 25,000 inhabitants. The town is a separate sanitary district, but contains the workhouse for the whole union. It is evident that the mortality rate for the town would in this case be represented as larger than it really is if no correction were made for the deaths which occur in the workhouse; while, on the other hand, the death-rate of the surrounding rural district would be less than it should be, unless the quota of in-door pauper deaths belonging to it is added. In populous urban districts, however, if the number of deaths occurring amongst strangers be not excessive, they may fairly be included in calculating the death-rate, because in this case they may be considered as representing the deaths of those persons belonging to the district who have died elsewhere.

Coming now to the calculation of death-rates, the first point which has to be determined is the actual or estimated population of the district. The actual

population is of course only ascertained every ten years, when the census is taken, or when a house-to-house survey giving the number of inmates in every house is made. The estimated population, therefore, is the basis on which the death-rate is calculated, and this is ascertained according to the method pursued by the Registrar-General in the following manner:—Add to the population of the district as enumerated at the last census a tenth of the difference between that number and the number obtained at the previous census for each year that has elapsed since the last census. Assuming now that the increase during the ten years has been maintained at a steady progressive rate, it is evident that this will give the estimated population for the end of the first quarter of any given year, that being the period of the year at which the census is taken. But inasmuch as the death-rate is calculated on the estimated population of the district at the close of the second quarter or middle of any year, it is further evident that a fourth part of the annual increment, or a fortieth part of the actual increase of population which has taken place between the two census, must also be added to represent the increment for the additional quarter. Thus we will suppose that it is required to find the estimated population for the year 1877, of a town which at the census of 1861 contained 62,341 inhabitants, and at the census of 1871, 63,487 inhabitants. In this case the difference between the two census returns is 1146, and the average annual increase during the decennial period was therefore 114·6. In 1877 six years will have elapsed since the last census, and hence the estimated population at the close of the first quarter of that

year will be 63,487 + 687·6, and at the close of the the second quarter it will be

$$63{,}487 + 687{\cdot}6 + 28{\cdot}6 = 64{,}203,$$

and this number will represent the estimated population of the town, according to which all the death-rates for the year should be calculated. The simple problem stated in arithmetical detail stands thus:—

	Population.
Census 1861	62,341
" 1871	63,487
Difference	1,146

Average annual increase (1861-71) = 114·6.

Therefore estimated

$$\text{Pop. for } 1877 = 63{,}487 + (114{\cdot}6 \times 6) + \frac{114{\cdot}6}{4} = 64{,}203.$$

In new and rapidly increasing districts, it will often happen that this estimate falls short of the mark, and in such cases it is desirable when possible to ascertain the number of inhabited houses for the year, which may generally be obtained from the assessment books. An approximately correct estimate of the population can then be obtained by multiplying the average number of inhabitants per house, which can be ascertained without much trouble, by the number of occupied houses.

After having estimated the population for the year, the next point is to determine the various death-rates. The method adopted by the Registrar-General is thus graphically described in *The Sanitary Record*, August 7, 1875:

"In the first place, it is scarcely necessary to say that all the

rates now published by the Registrar-General, whether they relate to a year, a month, or a week, are annual rates to 1000 persons living; that is, these published rates represent the number of persons who would die in a year in 1000 of each population, if the proportion of deaths to population recorded in the shorter periods of a week, or a month, or a quarter, were maintained throughout a whole year.

"Let us take a rate of mortality from the Registrar-General's last weekly return relating to the seven days ending July 31 as an example. We find in Tables 1 and 2 of that return it is stated that the estimated population of the borough of Sheffield in the middle of 1875 is 267,881 persons; that 127 deaths were recorded within the borough during the week under notice; and further that these deaths were equal to an annual rate of 24·7 per 1000 of this estimated population. Now for the operation by which this result is arrived at. We have the deaths in a week, and the estimated population in which they occurred; it is desired to find the number of the deaths which would occur in each 1000 of this population, if the same number of deaths were recorded in each week throughout a year. If a week were the correct fifty-second part of a year, it is obvious that either the deaths must be multiplied by fifty-two or the population be divided by fifty-two, in order to make the population and the deaths comparable. As, however, the correct number of days in a natural year is 365·24226, the number of weeks in a year is 52·17747. The Registrar-General, therefore, for the purpose of this weekly return, divides the estimated population of each of the towns dealt with by 52·17747, which gives what may be called the weekly population of each town. The population of Sheffield divided by 52·17747 gives a weekly population of 5134 persons; this number serves as constant throughout the year 1875, by which to divide the number of deaths. The 127 deaths in Sheffield during the week ending July 31st, divided by this so-called weekly population, gives an annual rate of 0·0247 to each person of the population; and by removing the decimal point three places to the right, or in other words multiplying by 1000, we arrive at 24·7, which is the correct annual rate of mortality per 1000 of the estimated population of the borough of Sheffield during that week. It would undoubtedly be more logical to multiply the deaths by 52·17747, than to deal with the population; but this operation would have to be repeated each week,

whereas there is a manifest convenience, and an arithmetical economy, in the reverse operation (the effect of which is, of course, identical), which supplies us with a constant that is applicable throughout the fifty-two weeks of 1875 For all practical purposes the multiplication of the deaths in a week by fifty-two, in order to divide them by the estimated population, will afford the means of arriving at an approximately correct annual rate of mortality; or the reverse operation, the division of the population by fifty-two, may be resorted to.

"For the calculation of annual rates of mortality in a month or a quarter the Registrar-General takes account of the number of days in each month or quarter, and it is found more convenient to deal with the population according to the method described in the calculation of the annual rate of mortality in a week. The populations to be dealt with are divided by 365·24226, and must then be multiplied by the number of days in a month or a quarter, in order to arrive at the population which may be applied to the deaths in a month or a quarter; by this means a scientifically correct annual death-rate in those respective periods will be obtained. Approximately correct annual rates of mortality in a month or a quarter may be calculated by using a twelfth or a quarter of the population respectively, as the divisor of the number of deaths recorded in those periods; but, inasmuch as the length of a month varies from twenty-eight to thirty-one days, and of a quarter, from ninety to ninety-two days, it is evident that a correct annual rate of mortality can only be calculated by taking into account this variation in the number of days in those periods, and that rates calculated without correction for these inequalities will differ from the rates published by the Registrar-General.

"In conclusion, it may be noted that rates published in the quarterly returns of the Registrar-General for the eighteen largest English towns relate to the period of thirteen weeks most nearly corresponding with the natural quarter, and that the population employed in this calculation is thirteen times that used for the rates in each week, and differs slightly from the population that would be used if the period of observation were three entire calendar months instead of thirteen weeks. The facts published in the quarterly return for all other parts of the country, except the eighteen largest English towns, relate to the natural quarters of three calendar months, and the population

used to produce the annual rates of mortality therein are manipulated in the manner before described."

Although the method of calculation thus described should be adopted in dealing with the statistics of all large towns and populous districts, a less complicated method will give sufficiently accurate results for small urban or rural districts. Thus we will suppose that the number of deaths registered in a district with an estimated population of 11,342, during a quarter of the year amount to 56, the annual death-rate per 1000 represented by this number would be approximately determined as follows:—

$$\frac{56 \times 4 \times 1000}{11{,}342} = 19{\cdot}7.$$

Besides the annual death-rate, the other rates which are usually given in statistical reports are the birth-rate, the rate of infant mortality, and the death-rate from zymotic disease.

The birth-rate is of course calculated in the same way as the death-rate, and is stated at so many per 1000 per annum.

The rate of infant mortality is usually measured by the proportion of deaths under one year to births registered, and is also expressed as so many per 1000. Thus we will suppose that the deaths of children under one year of age during the quarter amounted to 28, and that the births during the same period amounted to 225; the rate of infant mortality estimated in this way will therefore be:—

$$225 : 1000 : : 28 : X\,,$$

$$\text{or } X = \frac{28 \times 1000}{225} = 124.$$

Or the rate of infant mortality may be stated as a percentage of the total deaths. For example, let us suppose in the above instance that the deaths during the quarter amounted to 126, the percentage of deaths of children under one year will then be:—

$$\frac{28 \times 100}{126} = 22{\cdot}2.$$

The zymotic death-rate, or for that matter the death-rate from any disease or class of diseases, is calculated in the same way as the total annual death-rate, and is expressed as so many per 1000 of the population. Thus we will suppose that in a population of 22,438, the deaths from the seven principal zymotic diseases, as stated in the Registrar-General's returns during the year, amounted to 48; the zymotic death-rate per 1000 would in this instance be:—

$$\frac{48 \times 1000}{22{,}438} = 2{\cdot}1.$$

If it be desired to calculate the death-rate among persons of any given age, it is of course necessary to ascertain approximately the number of persons living in the district at that age, and this information can be obtained from Vol. iii. of the last Census Report. In making the calculation, it may be fairly assumed that the estimated population at all ages is distributed in the same proportions as was the enumerated population in 1871.

In order to calculate the mean age at death of a population, all the ages at death, during a given period, are added up, and this sum is divided by the total number of deaths. The mean age at death in England is about forty years.

In drawing conclusions from statistical data, it need hardly be said that great care must be taken to guard against fallacies. For example, the death-rate of the whole of a district may be comparatively low by reason of the preponderance of adult or selected lives, while the sanitary conditions are anything but satisfactory; or, again, the total death-rate may still not be above the average, while the death-rate in certain portions of the district may be excessively high. Indeed, as regards the special value of death-rates as a test of sanitary condition, it has been urged by the late Dr. Letheby, Dr. Tripe, and others, that they are utterly fallacious and unreliable on account of certain disturbing influences, such as the varying proportion of the two sexes in a population, the varying proportion of persons living at different ages, the influence of estimates of population in impairing the value of death-rates, and the effect of migration. It has, however, been clearly shown by Mr. Humphry (see *Sanitary Record*, 1874), that even if the maximum of influence were accorded to these disturbing causes, the resulting differences are exceedingly small, and as a matter of fact they have always been taken into account by the Registrar-General so far as circumstances would allow. But while this holds good in respect to large populations, there is no doubt that some of these disturbing influences do affect the death-rates of small urban and rural districts very materially. For example, there is a small urban district under my own supervision, which in 1874 contained an *enumerated* population of 828, and the death-rate for the year was as low as 6·1 per 1000, while in 1875 it was only 12 per 1000. In this instance the exceptionally low death-rate is

accounted for by the preponderance of adult and selected lives, there being in the majority of houses in the district a large staff of servants. In another urban district similarly circumstanced with an estimated population of 2047, which I have reason to believe is not over the mark, the death-rate for 1875 was only 9·4 per 1000. Now, although it be true that as regards both these districts the sanitary condition is very satisfactory, it is evident that, comparing them with other districts, the death-rate would be no reliable test of that condition. These are, of course, exceptional instances, but many others might be quoted to show that the total death-rate, while it may be considered as a test of some considerable value, as regards the sanitary condition of large communities, cannot be depended on when commenting upon the vital statistics of small urban or rural districts.

Generally speaking, the effects of sanitary improvements and precautionary measures are best indicated by a lowered death-rate from infectious diseases, fever, diarrhœa, and phthisis, and, amongst children under five years, from all causes. Indeed, it may be said that the death-rate of children under five years of age is in many places a far more reliable criterion of the sanitary conditions affecting the health of a community, than the total average mortality rate, even although every allowance is made for neglect, deficiency of food, mal-nutrition, and exposure. Nor, again, in drawing inferences from mortality returns, must the influence of social causes of disease be forgotten, for the effects of intemperance, immorality, and injudicious marriages, especially amongst the lower classes in all our large towns, can scarcely be over-

estimated. (See Chapter I.) Indeed, there is no doubt that drink and immorality have as large a share in producing a high death-rate amongst crowded populations as the insanitary conditions of their surroundings.

In these plain and practical hints, it is not necessary to discuss the more complicated problems of vital statistics. What is required of the medical officer of health is that he should classify his returns honestly and with no preconceived ideas as to what the figures are to prove; and although mistakes may sometimes be made in diagnosis, he is bound to classify the returns as he receives them, unless after due inquiry he is convinced that in exceptional cases such mistakes have been made. Even then it is essential, as a statist, that he should present the returns as they are sent in to him; and if he has reason to question their accuracy, he should honestly state his reasons, after as far as possible consulting with the medical attendant. This of course is always a delicate matter, requiring the utmost tact and conscientiousness, because under any circumstances it is an interference liable to be resented, and especially if the medical officer of health is not precluded from practice. But, whether the medical officer of health is in practice or not, enough has been said to show not only the necessity of constant and systematic attention on his part to the vital statistics of his district, but also the immense assistance which a logical use of them will afford him in estimating rightly the separate or combined influences of avoidable or removable causes of disease.

SECTION IV.—DUTIES REQUIRED OF THE MEDICAL OFFICER OF HEALTH FOR THE EFFICIENT EXECUTION OF THE SANITARY ACTS.

As the health officer must "be prepared to advise the sanitary authority on all points involved in the action of the sanitary authority or authorities," it is necessary that he should make himself acquainted with the Public Health Act of 1875, and the other Acts or portions of them which more immediately concern his office. Previous to the consolidation of the various Sanitary Acts in the Public Health Act of 1875, the task of wading through these numerous enactments, so as to obtain a practical knowledge of the clauses affecting the duties of the health officer, was by no means an easy one. All this, however, is now very much simplified, and the only Acts which the health officer need consult, may be confined, with a few exceptions, to the Public Health Act 1875, and the Artizans' Dwellings' Act 1875, the latter of course only applying to large towns. And here it may be observed that though the Public Health Act permits the medical officer of health to exercise any of the powers with which an inspector of nuisances is invested, it is not his duty to search for nuisances. By all means let him make an inspection whenever he deems it necessary, or when he has reason to believe that the sanitary inspector is not properly attending to his duty, but he should avoid as far as possible interfering with matters which in the first instance concern the office of the surveyor or sanitary inspector. He should nevertheless be fully qualified to advise and

give suggestions, and in order to do so it is essential that he should be well acquainted with practical details. The clauses in the Public Health Act, to which special attention should be directed, are classed in order as they appear in the list, under the following headings:—

1. *Sewerage and Drainage* (clauses 13-26).—The two most important clauses in this section, so far as the medical officer of health is concerned, are, clause 19, which makes it incumbent on every local authority to have all sewers constructed, ventilated, and kept so that they shall not be a nuisance; and clause 23, which empowers local authorities to enforce the drainage of undrained houses, such drainage to be carried out in all particulars to the satisfaction of the surveyor. (See Chapter XI.)

2. *Privies, Water-closets, etc.* (clauses 35-41).—These clauses give full powers to sanitary authorities to enforce closet accommodation, and to provide that all drains, water-closets, earth-closets, privies, ashpits, and cesspools, within their district, be constructed and kept so as not to be a nuisance or injurious to health. With regard to structural details, and especially the alterations which are required to remedy the defects which are so commonly connected with the closet accommodation of rural districts, see Chapter XI.

3. *Scavenging and Cleansing* (clauses 42-47).—By virtue of these clauses, sanitary authorities are empowered, or they may be required by order of the Local Government Board, to provide for the cleansing of streets and the removal of refuse; and in localities where the scavenging is undertaken by the sanitary authority, any occupier of premises may claim a penalty not exceeding five shillings a day from the

local authority if they neglect, after due notice, to cleanse any earth-closet, privy, ashpit, or cesspool, belonging to such premises. In all cases, therefore, where the medical officer of health is convinced that public scavenging has become necessary, he ought to urge that this duty be undertaken by the sanitary authority, and if they refuse to comply with his request, he should have no hesitation in appealing to the Local Government Board to issue the necessary order. In places where there is no public scavenging, the local authority may make bye-laws imposing the duty of cleansing footways and pavements adjoining premises, and of removing all offensive refuse from the premises, on the occupier. Clause 46 gives power to order the cleansing and purifying of houses on the certificate of the medical officer of health; and clause 47 imposes penalties in respect to certain nuisances occurring on premises in urban districts. (See Chapter XI.)

4. *Offensive Ditches and Collections of Matter* (clauses 48-50).—These clauses provide for the obtaining of orders for cleansing offensive ditches lying near to or forming the boundaries of districts; for the removal of filth-accumulations on the certificate of the sanitary inspector; and for the periodical removal of manure from mews and other premises in urban districts.

5. *Water Supply* (clauses 51-70).—These clauses relate to the general powers of sanitary authorities for supplying their districts with water, whether by water-works or wells; to provisions for the protection of water-supplies against pollution; and to the closing, cleansing, or repairing of polluted wells. (See Chapters VI. and VII.)

6. *Regulation of Cellar-Dwellings and Lodging-Houses* (clauses 71-90).—Besides prohibiting the occupation of cellars absolutely, or only under certain conditions, these clauses provide for the registration of common lodging-houses, and the issuing of bye-laws for their regulation, and they also empower the Local Government Board to authorise the local authority to make bye-laws in respect to houses other than common lodging-houses which are let in lodgings, or occupied by members of more than one family. As regards watering-places, and other fashionable health-resorts, this last provision is one of great importance, inasmuch as it would not only ensure the removal of any sanitary defects from houses let in lodgings, but it also renders it compulsory on lodging-house keepers to give immediate notice to the sanitary authority in cases of infectious disease, and to take proper precautions.

7. *Nuisances* (clauses 91-111).—As this section of the Public Health Act is a very important one, it may be considered more fully in detail. The several classes of nuisances are defined by the Act as follows:—

(1.) "Any premises in such a state as to be a nuisance or injurious to health."

It need hardly be said that this definition, by reason of its vagueness, includes a great variety of sanitary defects, and, like the other definitions, implies injury to health, whether probable or actual, as a consequence of the nuisance. Unfortunately, too, this vagueness is, if possible, still further increased by the definition in the preamble of the Act, which states that "*lands* and *premises* include messuages, buildings, lands, easements, and hereditaments, of any tenure." All this gives ample room for legal quibbles, but so

far as the duties of the medical officer of health and the sanitary inspector are concerned, there is usually little difficulty experienced in carrying out the intention of the Act. The sanitary defects implied in the definition have reference, for the most part, to the cleansing or whitewashing of dirty houses ; the repair of roofs that let in the rain; the repair of walls and uneven floors; the opening of fastened windows to improve the ventilation; the removal of privies or pigsties abutting against outside walls; the prevention of dampness as far as possible; the repair of yards, and, especially in rural districts, the sanitary improvement of farm-yards adjoining the dwelling-houses. When it is not possible to put a house into habitable repair, or when the necessary repairs are not carried out in compliance with the notice issued by the sanitary inspector, power is given, by clause 97, to close the house by order of a Justice. With regard to the difficulties of dealing with the question of defective house-accommodation, see Chapter IX.

(2.) "Any pool, ditch, gutter, water-course, privy, urinal, cesspool, drain, or ashpit, so foul, or in such a state, as to be a nuisance or injurious to health."

This definition requires no further comment than this, that whenever any offensive smell is given off by any pool, ditch, etc., whether it be in the proximity of dwellings, or near any frequented road or footpath, there is sufficient evidence of the existence of a nuisance which calls for removal. All foul privies, cesspools, and drains in rural districts can be dealt with under this clause.

(3.) "Any animal so kept as to be a nuisance or injurious to health."

This definition applies to pig-styes, fowl-pens, dog-kennels, cow-byres, etc. In dealing with nuisances of this description, it often happens that the abatement may be effected in various ways. For example, a nuisance arising from a pig-stye may be abated sometimes by keeping the animal in a more cleanly way, by lessening the number of pigs, by properly draining the pig-stye, by removing the pig-stye if it be too near a dwelling, or too near a frequented path, or by prohibiting the keeping of pigs altogether. It may safely be laid down as a rule, that pig-styes close to dwellings, or under bed-room windows, will always be more or less a nuisance, no matter how carefully the animal may be kept.

(4.) "Any accumulation or deposit which is a nuisance or injurious to health."

In this definition are included offensive manure-heaps, or other filth-accumulations, which are close to dwellings or frequented paths. It also applies to offensive refuse heaps of every description,—the only exception being made "in respect of any accumulation or deposit necessary for the effectual carrying on any business or manufacture, if it be proved to the satisfaction of the Court that the accumulation or deposit has not been kept longer than is necessary for the purposes of the business or manufacture, and that the best available means have been taken for preventing injury thereby to the public health."

(5.) "Any house or part of a house so overcrowded as to be dangerous or injurious to the health of the inmates, whether or not members of the same family."

In previous parts of this work the necessity for an

ample amount of cubic space for the requirements of perfect health has been strongly insisted on—an amount, however, which it is impossible to obtain or enforce in the dwellings of the poorer classes, and in common lodging-houses. Practically it is found that 300 cubic feet per head is the highest *minimum* which can be enforced in most large towns, and even that amount cannot be exacted in the case of many families consisting of husband and wife and young children. In rural districts also the difficulty of dealing with this form of nuisance on reasonable and equitable grounds is quite as great as it is in towns, if not greater; and as an instance in point, I may quote the following remarks from one of my reports for 1874:—"In places where there is a scarcity of houses, it is evidently impossible to abate the nuisance to any extent, because in attempting to reduce the overcrowding in one part you only increase it elsewhere. But in Mid-Warwickshire this difficulty has not arisen, partly because the district is mainly agricultural and can only maintain a limited number of the labouring class, and partly, too, I have no doubt, because during the last two or three years there has been a considerable exodus from a good many of the villages in consequence of the agricultural labourers' movement. The cases of overcrowding met with have been generally confined to single families occupying houses with only one sleeping-room, and in endeavouring to deal with this form of nuisance there were several points which had to be considered. In the first place, it was clear that if the minimum allowance of cubical space per head was made too high, the instances of overcrowding, judged by this standard,

would have become so numerous that any attempt to deal with them would have been impossible; in the second place, the ages of the children had to be taken into account; and in the third place, it became a question whether in condemning a house as being too small for the family, another and suitable one was to be found in the village. With regard to cubical space, it appeared to me, after careful inquiry into the average amount of sleeping accommodation, that the standard of 200 cubic feet per head was as high as it could be raised for families consisting of parents and young children, though at the same time I am free to confess that a minimum of 300 cubic feet space, even with good means of ventilation, is little enough for the requirements of health. But in cases where it was found that grown-up children of both sexes slept in the same room, or in the same room with their parents, the question of cubic space became a matter of secondary consideration, and the plea of overcrowding has been insisted on in the interests of decency as much as on the score of health. It will thus be seen that the cases of overcrowding met with had to be decided according to the special circumstances of each rather than in accordance with any fixed rules, and though the minimum cubic space which has been adopted is small, it must be borne in mind that the dilapidated state of most of the cottages permits a freer interchange of air than is usually to be obtained in newer and better built houses. All this is, of course, an admission that only the more glaring cases of overcrowding have been dealt with; but with so many cottages containing only one sleeping-room, and taking into consideration the size of [illegible], it is impossible to

lessen the extent of the evil except by acting on principles such as these. As it is, many cases of overcrowding have been abated, and the notices issued by the Inspectors have been so generally complied with that only a few cases had to be brought before the Magistrates."

(6.) "Any factory, workshop, or workplace (not already under the operation of any general Act for the regulation of factories or bakehouses), not kept in a cleanly state, or not ventilated in such a manner as to render harmless as far as practicable any gases, vapours, dust, or other impurities generated in the course of the work carried on therein, that are a nuisance or injurious to health, or so overcrowded while work is carried on as to be dangerous or injurious to the health of those employed therein." (See Chapter III.)

(7.) "Any fireplace or furnace which does not so far as practicable consume the smoke arising from the combustible consumed therein, and which is used for working engines by steam, or in any mill, factory, dyehouse, brewery, bakehouse, or gas-work, or in any manufacturing or trade process whatsoever; and any chimney (not being the chimney of a private dwelling-house sending forth black smoke in such quantity as to be a nuisance, shall be deemed to be nuisances liable to be dealt with summarily in manner provided by this Act;" provided always that it can be shown that the best practical means have been adopted to consume the smoke, having regard to the manufacture or trade, and that due care has been exercised by the person in charge of the same.

In order to obviate nuisances of this description, all furnaces or factory fireplaces should have chimneys of

sufficient height, and should be provided with a smoke-consuming apparatus. Very often it is found that nuisance arises from neglect in stoking.

8. *Offensive Trades* (clauses 112-115).—By these clauses power is given to urban sanitary authorities to restrict the establishment of offensive trades in their districts, such as bone-boiling, soap-boiling, tallow-melting, etc.; to make bye-laws with respect to the same; and to direct complaint to be made before a justice, if the effluvia given off are certified to be a nuisance or injurious to health, by the medical officer of health, or by two legally qualified practitioners, or by any ten inhabitants of the district. Before a conviction can be obtained in respect to established trades, it will be necessary to prove to the satisfaction of the court that the best practical means for the abatement of the nuisance have not been adopted; and as the medical officer of health is liable in most cases to be called upon to give skilled evidence, it is necessary that he should be well acquainted with the process of manufacture, or the details of the trade complained of, the nature of the effluvia given off, and the best means which should be adopted to prevent nuisance. Such knowledge can, of course, only be obtained by inspecting offensive trades, and it must necessarily be supplemented by a thorough acquaintance with practical chemistry. Unless the medical officer of health is an expert in these matters, the best course to pursue is to recommend the manufacturer or tradesman, against whom complaint is made, to call in some competent person to advise him as to what steps he should take to prevent nuisance; and in the event of no steps being taken, he should recommend the sanitary authority to

consult an expert, who would give evidence before the magistrates if necessary.

With proper precautions the manufacturer of offensive products may, in the great majority of instances, carry on his trade without causing serious nuisance to the neighbourhood, and not unfrequently finds it advantageous even as regards pecuniary interests when he is compelled to utilise his waste offensive refuse. Without entering into details, it may be said generally that all foul matters should be conveyed to the works in properly constructed vans or tanks, which can be covered with tight-fitting lids, and that they should be stored in closed chambers or tanks, ventilated, if necessary, into the furnace fires, or to special scrubbers. All foul processes, such as oil-boiling, tallow-melting, and the like, should be carried on in boilers with tight-fitting lids, and the effluvia given off should be conducted first to a condenser to get rid of the steam if necessary, and then to the furnace-fire to be consumed. The sulphuretted hydrogen and ammonium compounds which are given off in the manufacture of salts of ammonia from gas-liquor, should also be conducted from the vats to the furnace-fire to be burnt. Again, all gases and vapours which can be condensed or absorbed should be passed through condensers or absorbents specially suited for them, as, for example, water in the form of spray, or scrubbers charged with water, sulphuric acid, or alkaline solutions.

9. *Unsound Meat, etc.* (clauses 116-119).—These clauses empower the medical officer of health or inspector of nuisances to inspect and examine, at all reasonable times, " any animal, carcase, meat, poultry

game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk, exposed for sale, or deposited in any place for the purpose of sale, or of preparation for sale, and intended for the food of man."

In carrying out his duties in this respect, it is advisable that the medical officer of health, when he is not called in by the sanitary inspector, should get that officer, or failing him a policeman, to seize the condemned articles in order to have them dealt with by a justice. The onus of proving that the article seized was not exposed or deposited for sale, or for preparation for sale, or was not intended for the food of man, rests upon the person charged. Very often, with regard to bad meat, the defence set up is that the article seized was not intended for the food of man, but for feeding dogs or to be boiled down with other offal as the case may be. So far, however, as the medical officer of health is concerned, he should endeavour, as far as possible, to confine his evidence to the question as to whether the article seized is or is not fit for the food of man, leaving the rest of the evidence to be given by the sanitary inspector or other witnesses. Various practical hints concerning the examination of different articles of food have already been given in Chapter II., while medical officers of health, who are also appointed as public analysts under the "Sale of Food and Drugs Act, 1875," must be specially qualified.

10. *Infectious Diseases, Hospitals, Mortuaries,* etc. (clauses 120-143).—This part of the subject has already been so fully discussed in previous chapters that little more remains to be said. The medical officer of health will have to consider whether, in the event of an outbreak of epidemic disease occurring in

his district, there can be procured at short notice sufficient means of isolation. It is true that in some rural districts the population is so very scattered that hospital accommodation is not required, because sufficiently protective measures can be adopted by quarantining as far as possible any infected houses, and by supplying properly trained nurses if they should be wanted, who may be paid either by the sanitary authority, or, in the case of paupers, by the board of guardians. When an outbreak threatens to be serious, a strict watch should be kept on all houses where infectious disease is known to exist, and there should be no hesitation in summoning any one who wilfully or carelessly offends against any of the clauses of the Act. In order that there may be no excuse for pleading ignorance in this respect, the sanitary inspector should be supplied with placards containing the necessary precautions to be taken (see Appendix), a copy of which he should leave at every infected house. In inquiring into the origin of any outbreak, or in giving instructions with regard to preventing its spread, it need hardly be said that the medical officer of health should be very careful not to examine any case without first requesting the sanction of the medical attendant, and unless he has reason to believe that an error has been made in the diagnosis, he should never question the accuracy of any returns which may be made to him. He will also have to consider whether it is necessary that any schools should be closed, and in recommending that such a step should be taken, he should always give a certificate in the case of public elementary schools, in order that the teacher may not

be deprived of the government grant which is allowed on the average attendance of the pupils.

With regard to the special provisions of this section of the Act, it may be pointed out that it is imposed as a duty on all sanitary authorities to cause premises to be cleansed or disinfected, and they are further empowered to direct the destruction of any bedding, clothing, or other articles, which cannot otherwise be safely disinfected, and to pay for the same; to supply means of disinfection if necessary; and to provide ambulances, hospitals, and mortuaries. They may either build such hospitals or places of reception, or contract for the use of any such hospital, or part of a hospital, or place of reception; or enter into any agreement with any person having the management of any such hospital; or two or more authorities may combine in providing a common hospital. In populous districts, it is always advisable that a proper hospital should be erected, and in small urban and rural districts, it will often be found that such hospital accommodation can be most economically and efficiently provided by combination of neighbouring authorities. The term place of reception will include any house which may be rented for the reception of infectious cases, or any hut or tent, or, in the case of seaport towns, any hospital ship.

Clause 132 empowers a sanitary authority to recover the cost of maintenance of any patient who is treated in any such hospital, who is not a pauper; but inasmuch as the removal of a patient to a hospital may be said to confer as great a benefit on the public as it does on the patient, the enforcement of payment would not only be manifestly unfair in many cases,

but would tend greatly to diminish the usefulness of such hospital. According to clause 124 the only persons who can be removed to an infectious hospital by order of a justice, on a certificate signed by a legally qualified practitioner, are the following: any person who is suffering from any dangerous infectious disorder, who is without proper lodging or accommodation, or lodged in a room occupied by more than one family, or is on board any ship or vessel; or any person so suffering who is lodged in any common lodging-house. With proper tact, however, on the part of the medical officer of health in enlisting the co-operation of medical attendants, and readiness on the part of the sanitary authority to attend to his recommendations, there will generally be little difficulty experienced in inducing most patients to enter the hospital who are fit to be removed, and whose removal is considered advisable for the public safety.

Although the sanitary protection afforded by hospitals, mortuaries, disinfecting apparatus, and the like, is now placed beyond dispute, it unfortunately happens that sanitary authorities, as a rule, are very slow to exercise the powers vested in them in this respect, unless under the pressure of an epidemic, and consequently the recommendations of the medical officer of health to be prepared beforehand are often thrown aside. But this need not discourage or annoy him in any way. His plain duty is to study carefully the requirements of his district, and having done this, to submit his views as clearly and as concisely as he can to the sanitary authority, using the best arguments he can advance to support his case, showing every readiness to answer any questions, and being fully

prepared to meet any objections. If his recommendations are not complied with, the onus will rest on the sanitary authority and not on him; but at the same time he should be careful to bring them forward on some future occasion, when very likely they will either meet with acceptance, or at all events some efforts will probably be made to carry them out.

Clauses 134 to 140 empower the Local Government Board, whenever any formidable outbreak takes place in any part of England, to make regulations for the speedy interment of the dead, for house-to-house visitation, for medical aid and accommodation, and for other means to prevent the spread of disease; but it will only be in cases of the gravest emergency, and when the health of his district is seriously endangered, that the medical officer of health will feel it incumbent on him to recommend the enforcement of these clauses.

In all cases of infectious disease, care should be taken to ensure as far as possible the right use of disinfectants, and it is always a wise economy on the part of sanitary authorities to supply disinfectants, gratuitously to those who are too poor to buy them. Moreover, as it is the duty of the sanitary authority to take care that disinfection is efficiently carried out, the sanitary inspector, under the direction of the medical officer of health, should himself superintend or assist in the process of the disinfection of rooms, etc., or in populous districts some one should be specially appointed to act as a disinfector.

For detailed information with regard to hospitals, infectious disease, etc., see Chapters X. and XIV., and Appendix.

11. The other clauses in the Public Health Act which are of special interest to the medical officer of health are the following, and they apply exclusively to urban districts or districts provided with urban powers:—

Clause 157 gives power to make bye-laws respecting new buildings, etc.

Clause 164 empowers an urban sanitary authority to provide places of public recreation.

Clause 166 gives power to provide markets.

Clauses 169-170 give power to provide public slaughter-houses, and to regulate private slaughter-houses.

In Schedule IV. of the Act will be found the various legal forms of notice for requiring the abatement of nuisance, summons, etc., but these concern the clerk and sanitary inspector more than they do the medical officer of health.

12. The other Acts which have not been repealed by the Public Health Act, to which reference may be made, are the Artisans' and Labourers' Dwellings' Act, the Bakehouse Regulation Act, and the Baths and Washhouses' Act, but as the essential provisions of these are included in the bye-laws of all urban districts in which they are in force, they need not be further considered here.

In towns containing a population of 25,000 and upwards, as enumerated at the last census, an important duty will devolve upon the medical officer of health of recommending the adoption of the Artisans' Dwellings' Act of 1875, when any houses, courts, or alleys, within a certain area of his district, are unfit for habitation by reason of their unhealthiness, and

when the sanitary defects in such area cannot be effectually remedied otherwise than by an improvement scheme. As the local authority cannot carry out the intentions of the Act without an official representation made by the medical officer of health, and as he is bound by the Act to make such representation whenever he sees cause for the same, it need hardly be said that the duty imposed upon him will demand the utmost care and conscientiousness on his part.

13. *Bye-laws.*—In all urban districts, the medical officer of health will find that bye-laws have already been framed, and as a matter of course he should at once make himself thoroughly acquainted with their details, and more especially with those which relate to the removal of refuse and the prevention of nuisance, the sanitary arrangements of new buildings, and the inspection and regulation of slaughter-houses, bakehouses, and common lodging-houses. Unfortunately, rural sanitary authorities have no power to issue byelaws with respect to new buildings, etc., unless they are provided with urban powers; but since these can be granted by the Local Government Board, it will become the duty of the medical officer of health to recommend that an application be made for the granting of such powers, whenever he feels assured that the sanitary requirements of his district demand them. As it has been announced that a code of model byelaws will soon be issued by the Local Government Board, it would be superfluous to quote any of those which are now in use.

14. *Legal Proceedings.*—Unless under exceptional circumstances, the medical officer of health shou[illegible] never conduct a case before the justices,—that is t[illegible]

duty of the clerk to the sanitary authority, or in respect to common nuisances it is often discharged by the sanitary inspector. Although he will often have to recommend that proceedings be taken, his duty so far as the prosecution is concerned should be confined to furnishing a certificate or giving evidence when required. With a well-trained inspector, it is seldom that he will be required to give evidence except as regards cases of overcrowding, infected houses or exposure of infected persons, clothing, etc., unsound meat, nuisances which are likely to be contested, and offensive trades.

15. *Routine of Duty.*—This of course will very much depend on the nature and extent of the district. It unfortunately happens that in many instances the appointment of medical officer of health is made under circumstances in which he is expected to do but little, and that little only when called upon by the sanitary inspector to certify or give evidence. But in all large urban or combined districts, it is necessary that the duties should be carried on as systematically as possible. As already stated, the sanitary inspector or inspectors should be under the supervision of the medical officer of health, and any orders from the sanitary authority affecting the duties of these officials should be conveyed through him or with his concurrence, otherwise he cannot be held responsible for the efficient working of his department. The following are the duties of the sanitary inspector as laid down by an order of the Local Government Board, dated November 11, 1872, and they apply to all inspectors who are appointed, subject to the approval of that Board :—

"The following shall be the duties of the inspector of nuisances in respect of the district for which he is appointed, or if he shall be appointed for more than one district, then in respect of each of such districts :—

"(1.) He shall perform, either under the special directions of the sanitary authority, or (so far as authorised by the sanitary authority) under the directions of the medical officer of health, or in cases where no such directions are required, without such directions, all the duties specially imposed upon an inspector of nuisances by the Sanitary Acts, or by the orders of the Local Government Board.

"(2.) He shall attend all meetings of the sanitary authority when so required.

"(3.) He shall by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed in respect of the nuisances existing therein that require abatement under the Sanitary Acts.

"(4.) On receiving notice of the existence of any nuisance within the district, or of the breach of any bye-laws or regulations made by the sanitary authority for the suppression of nuisances, he shall, as early as practicable, visit the spot, and inquire into such alleged nuisance or breach of bye-laws or regulations.

"(5.) He shall report to the sanitary authority any noxious or offensive businesses, trades, or manufactories established within the district, and the breach or non-observance of any bye-laws or regulations made in respect of the same.

"(6.) He shall report to the sanitary authority any damage done to any works of water supply, or other works belonging to them, and also any case of wilful or negligent waste of water supplied by them, or any fouling by gas, filth, or otherwise, of water used for domestic purposes.

"(7.) He shall from time to time, and forthwith upon complaint, visit and inspect the shops and places kept or used for the sale of butchers' meat, poultry, fish, fruit, vegetables, corn, bread, or flour, or as a slaughter-house, and examine any animal, carcase, meat,

poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, which may be therein; and in case any such article appear to him to be intended for the food of man, and to be unfit for such food, he shall cause the same to be seized; and take such other proceedings as may be necessary in order to have the same dealt with by a justice: Provided that in any case of doubt arising under this clause he shall report the matter to the medical officer of health, with the view of obtaining his advice thereon.

"(8.) He shall, when and as directed by the sanitary authority, procure and submit samples of food or drink, and drugs suspected to be adulterated, to be analyzed by the analyst appointed under the Adulteration of Food Act, 1872; and upon receiving a certificate stating that the articles of food or drink, or drugs, are adulterated, cause a complaint to be made, and take the other proceedings prescribed by that Act.

"(9.) He shall give immediate notice to the medical officer of health of the occurrence within his district of any contagious, infectious, or epidemic disease of a dangerous character; and whenever it appears to him that the intervention of such officer is necessary in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall forthwith inform the medical officer thereof.

"(10.) He shall, subject in all respects to the directions of the sanitary authority, attend to the instructions of the medical officer of health with respect to any measures which can be lawfully taken by him under the sanitary Acts for preventing the spread of any contagious, infectious, or epidemic disease of a dangerous character.

"(11.) He shall enter from day to day, in a book to be provided by the sanitary authority, particulars of his inspections and of the action taken by him in the execution of his duties. He shall also keep a book or books, to be provided by the sanitary authority, so arranged as to form, as far as possible, a continuous record of the sanitary condition of each of the premises in respect of which any action has been taken

under the sanitary Acts, and shall keep any other systematic records that the sanitary authority may require.

"(12.) He shall at all reasonable times, when applied to by the medical officer of health, produce to him his books, or any of them, and render to him such information as he may be able to furnish with respect to any matter to which the duties of inspector of nuisances relate.

"(13.) He shall, if directed by the sanitary authority to do so, superintend and see to the due execution of all works which may be undertaken under their direction for the suppression or removal of nuisances within the district.

"(14.) In matters not specifically provided for in this order, he shall observe and execute all the lawful orders and directions of the sanitary authority, and the orders of the Local Government Board which may be hereafter issued, applicable to his office."

In some valuable articles which appeared in the *Medical Times and Gazette* in Nov. 1872, on the duties of medical officers of health, the following sketch of the daily routine in a large metropolitan parish is given as a guide for commencing health officers :—

"At 9 A.M. the subordinate officers arrive at the office. They consist of a clerk, a messenger (who is always a copying clerk), the sanitary inspectors, to each of whom a district is assigned, and a disinfector. Shortly after, the medical officer arrives, reads his letters, confers with the clerk, gives directions as to the correspondence of the day, receives verbal reports from the inspectors as to the previous day's work, and makes appointments for these officers to meet him at particular places during the course of the day, should his presence be deemed necessary in particular cases. In a few minutes a large amount of routine work can thus be got through, whilst reports for committees, special correspondence, and the examination of the books of the department, can be despatched, say twice or thrice a week, at any convenient time. Between 9 and 10 A.M. each inspector writes

out a brief diary of his previous day's work for the information of the medical officer, and instructs the disinfector as to houses where disinfection is required. At 10 the sanitary inspectors depart on their daily rounds, having previously informed themselves as to any new complaints requiring their attention. After their departure the clerk extracts and summarises their diaries, and enters the results in the proper books. The books actually in use are—(1.) The medical officer's diary, in which he briefly enters the dates of visits made, with any particulars he thinks fit. (2.) A book for receiving the complaints of ratepayers and others. (3.) A record of houses in which infectious disease has appeared. (4.) The diaries of the several sanitary inspectors. (5.) A book recording the progress of works, which exhibits at a glance the visits made and the works executed at any particular house. From this the clerk extracts, and presents weekly to the medical officer—(6.) A list of works in arrear. (7.) A report book in which the health officer reports to the sanitary committee all ordinary cases of nuisances uncompleted, together with his recommendations. Further, the sanitary inspectors are provided with forms of notice of nuisances, arranged in books with duplicates, after the manner of a cheque-book. These arrangements may seem complicated. In practice, however, they are found to be simple and effective. Where little or no clerical assistance is furnished, they may be much simplified, and the books reduced in number."

In small urban or rural districts, and in combined districts when special clerical assistance is not required, the only book which it may be necessary to keep beyond filing statistics, reports, and any important official communications, is a diary, but this should always be kept, no matter how meagre the duties may be, because it will be frequently required for reference.

16. *Reports.*—All reports from the health officer to the sanitary authority should be concise and to the point. The stated reports, weekly, quarterly, or otherwise, will deal chiefly with the vital statistics of the district, and enumerate such proceedings as have been

undertaken, according to the provisions of the Sanitary Acts, together with any suggestions which he may deem it to be his duty to lay before the sanitary authority from time to time. He should avoid entering into lengthy disquisitions, because he will have the opportunity, at meetings of the sanitary authority, of answering any questions, and justifying his recommendations,.should he be called upon to do so. As far as possible he should base his stated reports on a uniform plan, and he may be quite sure that the briefer they are in their completeness, the more they will be appreciated. Annual reports should embrace all the points indicated in the regulations of the Local Government Board, previously quoted.

If his reports appear in the public newspapers of the district, as will generally be the case, he should endeavour, without being diffuse, to make them readable and instructive, and whenever he considers it necessary to address the public through this channel, with respect to any sanitary dangers to which they may be specially exposed, it is always advisable that his remarks should, in the first instance, be submitted to the sanitary authority. Although he will find the press to be of great assistance in educating the public in sanitary matters, it need hardly be said that he should avoid entering into controversy, and that he should be very careful not to drag the names of private individuals before the public when his reports are printed.

17. *Official Conduct.*—With regard to his subordinates, the medical officer should endeavour to arouse in them an *esprit de corps*, not doing their work, but seeing that they do it themselves efficiently and readily. He should listen courteously to any remarks or suggestions

which they may make, and if they are trained officers, give them credit for knowing their duties as well as he does his own. In their own sphere they are as sensitive to rebuke as himself, and it should, therefore, never be administered unless it is merited. Any serious delinquency or inefficiency on their part should be laid before the sanitary authority, and those who do perform their duties satisfactorily should be as frankly commended. Above all, punctuality should be insisted on. In cases where the health officer will have to educate sanitary inspectors who are new to the work, it would be desirable that all candidates for such an important post should pass a certain period of probation before their appointment is confirmed by the sanitary authority.

As regards the portion of the community committed to his charge, he should endeavour conscientiously, and to the best of his ability, to fulfil his obligations towards them, and if in practice, he should in no wise shirk his public duty, even at the risk of losing his best patient. In this, as in all other affairs of life and conduct, it will be found that in the long run "honesty is the best policy."

Towards his medical brethren he should religiously observe the ethics of his profession, and act up to the golden rule,—"Do to others as you would be done by." He should endeavour to be on friendly terms with all within his district, and never hesitate to court their assistance and advice when he feels that he may require them in the discharge of his duties. It need hardly be said that all such favours or obligations should be readily and ungrudgingly reciprocated on his part. If he is not debarred from private practice, he should be

careful, above all things, not to take advantage of his public office by using it as a means to increase the number of his patients. This, to say the least, would be a grave breach of professional etiquette, which would deservedly arouse remonstrance and opposition on the part of his medical brethren.

His relations to the sanitary authority or sanitary committee, as the case may be, should be guided by common sense and a sense of duty. He should always remember that he is their medical adviser, not their dictator; and at their meetings he should carefully avoid taking part in discussions on his reports, unless called upon to do so, or in reply to objections. He should attend all meetings at which his presence is requested or expected; and when he does attend, he should support his views, when called upon, with clearness, firmness, courtesy, and tact. His proposals may be rejected, but if they do not lie within the scope of the statutory enactments requiring their enforcement, he should never resent opposition, but again bring them forward on future occasions. But with regard to breaches of sanitary law, which in spite of his representations may be persistently ignored, he should unhesitatingly insist upon their being remedied, and, failing action, he can always appeal to the Local Government Board. It is to be hoped, however, that he will seldom meet with such unwarrantable opposition. Under all circumstances he should strive to exercise a wise forbearance when he can conscientiously do so, and on all occasions maintain a courteous, dignified, and friendly demeanour towards the sanitary authority, feeling assured that tact and good temper, like good words, " are worth much, and cost but little."

APPENDIX.

OFFICIAL MEMORANDA AND OTHER DATA.

I.—Memorandum on Hospital Accommodation, to be given by Local Authorities.—(See Chap. X.)

II.—Ambulances.

For the conveyance to hospital of patients who are sick with infectious disease, special carriages, which are known by the name of "ambulances," are necessary. Such carriages may be provided by Sanitary Authorities under § 24 of the Sanitary Act, 1866.* The following points have to be attended to in the provision and use of such carriages :—

1. If the ambulance be intended only for journeys of not more than a mile, it may be made so as to be carried between two people, or it may be on wheels and to be drawn by hand. If the distance be above a mile, the ambulance should be drawn by a horse. Every ambulance on wheels should have easy carriage-springs.
2. In the construction of an ambulance, special regard should be had to the fact that after each use it has to be cleansed and disinfected. The entire interior, and the bed-frame and bed, should be of materials that can be washed.
3. The ambulance should be such that the patient can lie full length in it ; and the bed-frame and bed should be movable, so that the patient can be arranged upon the bed before being taken out of his house.

* § 123 of the Public Health Act, 1875.

4. With an ambulance there should always be a person specially in charge of the patient; and a horse-ambulance should have a seat for such person inside the carriage.
5. After every use of an ambulance for infectious disease, it should be cleansed and disinfected to the satisfaction of a Medical Officer.
6. Both in very populous districts, and in districts which are of very wide area, it may often happen that more than one ambulance will be wanted at one time; and, in any district, if more than one infectious disease is prevailing, there will be an evident sanitary advantage in having more than one ambulance for use.

JOHN SIMON.

Medical Department of the Local Government Board,
December 1874.

III.—PRECAUTIONS against the INFECTION of CHOLERA.

1. As Asiatic Cholera is now prevailing in parts of the Continent of Europe, and may probably extend (or perhaps has already extended) to places which are in frequent and rapid communication with England, it is not unlikely that, within the next month or two, cases of the disease may be brought into the ports of this country.

2. The Order, now about to be issued, of the Local Government Board will give power to local Sanitary Authorities to deal with any such cases, if they arrive, in a way to protect the population, as far as practicable, against surprise. But as cases of choleraic infection have widely different degrees of severity, it is possible that some such cases, slightly affected, will, notwithstanding the vigilance of Local Authorities, be landed without particular notice in English sea-board towns, whence then they may advance to other, and perhaps inland, places.

3. Former experience of Cholera in England justifies a belief that the presence of imported cases of the disease at various spots in the country will not be capable of causing much injury to the population, if the places receiving the infec-

tion have had the advantage of proper sanitary administration; and, in order that all local populations may make their self-defence as effective as they can, it will be well for them to have regard to the present state of knowledge concerning the mode in which epidemics of Cholera (at least in this country) are produced.

4. Cholera in England shows itself so little contagious, in the sense in which small-pox and scarlatina are commonly called contagious, that, if reasonable care be taken where it is present, there is almost no risk that the disease will spread to persons who nurse and otherwise closely attend upon the sick. But Cholera has a certain peculiar infectiveness of its own, which, *where local conditions assist*, can operate with terrible force, and at considerable distances from the sick. It is characteristic of Cholera (and as much so of the slightest choleraic diarrhœa as of the disease in its more developed and alarming forms) that *all matters which the patient discharges from his stomach and bowels are infective.* Probably, under ordinary circumstances, the patient has no power of infecting other persons except by means of these discharges; nor any power of infecting even by them, except in so far as particles of them are enabled to taint the food, water, or air, which people consume. Thus, when a case of Cholera is imported into any place, the disease is not likely to spread, unless in proportion as it finds, locally open to it, certain facilities for spreading by *indirect infection.* In order rightly to appreciate what these facilities must be, the following considerations have to be borne in mind:—*first*, that any choleraic discharge, cast without previous thorough disinfection into any cesspool or drain, or other depository or conduit of filth, infects the excremental matters with which it there mingles, and probably, more or less, the effluvia which those matters evolve; *secondly*, that the infective power of choleraic discharges attaches to whatever bedding, clothing, towels and like things, have been imbued with them, and renders these things, if not thoroughly disinfected, as capable of spreading the disease in places to which they are sent (for washing or other purposes) as, in like circumstances, the patient himself would be; *thirdly*, that if, by leakage or soakage from cesspools or drains, or through reckless casting out of slops and wash-water, any taint (however small) of the infective material gets access to wells or other sources of

drinking-water, it imparts to enormous volumes of water the power of propagating the disease. When due regard is had to these possibilities of indirect infection, there will be no difficulty in understanding that even a single case of Cholera, perhaps of the slightest degree, and perhaps quite unsuspected in its neighbourhood, may, *if local circumstances co-operate*, exert a terribly infective power on considerable masses of population.

5. It might be supposed that, under those provisions of the Sanitary Acts which relate to precautions against dangerous infections of disease, security could be taken, as regards the infective discharges of Cholera, against various kinds of personal conduct which would be dangerous to the public health; above all, that, under those provisions or otherwise, the universal disinfection of such discharges could be enforced. Undoubtedly everything possible in this direction ought to be done, wherever a case of Cholera is known to exist; too much importance cannot be attached to the precaution of thoroughly disinfecting, without delay, all discharges from the stomach and bowels of persons suffering under the disease, and of disinfecting or destroying all bedding, clothing, towels, and the like, which such discharges may have imbued: and of course neither choleraic discharges, nor any slops which may contain traces of them, should ever (even when supposed to be disinfected) be cast into any position from which they may get access into drinking-water. But, although the duty of observing those precautions is one which ought never to be neglected, populations cannot prudently stake their lives on the chance that it will be completely fulfilled for them. Apart from all questions of negligence, the degrees of Cholera are too many, and the slight and incipient cases far too apt to escape observation, for any such defence against its infection to be more than partial. And therefore the main object for endeavour must be, TO SECURE EVERYWHERE SUCH LOCAL CIRCUMSTANCES THAT THE INFECTIVE MATERIAL, THOUGH NOT DISINFECTED, WOULD BE UNABLE TO SPREAD ITS INFLUENCE AMONG THE POPULATION.

6. The dangers which have to be guarded against as favouring the spread of Cholera-infection are particularly two. First, and above all, there is the danger of WATER-SUPPLIES which are in any (even the slightest) degree tainted by house-refuse or other like kinds of filth; as where there is outflow, leakage, or filtration, from sewers, house-drains, privies, cesspools, foul ditches

or the like, into springs, streams, wells or reservoirs, from which the supply of water is drawn, or into the soil in which the wells are situate; a danger which may exist on a small scale (but perhaps often repeated in the same district) at the pump or dip-well of a private house, or, on a large and even vast scale, in the source of public water-works. And secondly, there is the danger of breathing AIR which is foul with effluvia from the same sorts of impurity.

7. Information as to the high degree in which those two dangers affect the public health in ordinary times, and as to the special importance which attaches to them at times when any diarrhœal infection is likely to be introduced, has now for so many years been before the public, that the improved systems of refuse-removal and water-supply by which the dangers are permanently obviated for large populations, and also the minor structural improvements by which separate households are secured against them, ought long ago to have come into universal use.

So far, however, as this wiser course has not been adopted, temporary security must, as far as practicable, be sought in measures of a palliative kind.

(*a.*) Immediate and searching examination of sources of water-supply should be made in all cases where the source is in any degree open to the suspicion of impurity: and the water both from private and public sources should be examined. Where pollution is discovered, everything practicable should be done to prevent the pollution from continuing, or, if this object cannot be attained, to prevent the water from being drunk.

(*b.*) Simultaneously, there should be immediate thorough removal of every sort of house-refuse and other filth which has accumulated in neglected places; future accumulations of the same sort should be prevented; attention should be given to all defects of house-drains and sinks through which offensive smells are let into houses; thorough washing and lime-washing of uncleanly premises, especially of such as are densely occupied, should be practised again and again.

(*c.*) Disinfection should be very freely and very frequently employed in and round about houses, wherever there are receptacles or conduits of filth; wherever there is filth-sodden porous earth; wherever anything else, in or under or about the house, tends to make the atmosphere foul.

In the absence of permanent safeguards, no approach to security can be got without incessant cleansings and disinfections, or without extreme and constant vigilance against every possible contamination of drinking-water.

8. In view of any possibility that the infection of Cholera may again be present in this conntry, it is desirable that in each locality the public should ascertain to whom it practically has to look, in case of need, for its collective safety against such dangers as the above. The responsibility is, in a large proportion of cases, mixed. The most critical of all its branches, the responsibility of providing for the unpollutedness of water-supplies, is, in many very important places, in the hands of commercial companies; and it is to be hoped that these companies, informed, as they must be, of the calamitous influence which some of their number have exerted in previous epidemics of Cholera, will remember, if the disease shall again be present here, that each of them, in its daily distribution of water, has hundreds, or even thousands of human lives in its hands. But, except to that extent, the responsibility for local defences against Cholera, both as regards water-supply and as regards local cleanliness and refuse-removal, is vested in the local Sanitary Authorities, Urban and Rural. These Authorities are all, by law, so constituted, as to represent, in their respective areas of jurisdiction, the will of the local ratepaying population; and each such population has had almost absolute means of deciding for itself whether the district which it inhabits should be wholesomely or unwholesomely kept. It is greatly to be wished that the former of these alternatives had, from long ago, been the desire of every local constituency in the country; and it may fairly be believed that, in considerable parts of the country, conditions favourable to the spread of Cholera are less abundant than at former times of visitation. But it is certain that in very many places the conditions of security are wholly or almost wholly absent; and it is to be hoped that in all this large class of cases, the Authorities, under present circumstances, will do everything which, in the remaining time, can be done, to justify the trust reposed in them by the Legislature for the protection of the public Health.

9. It is important for the Public very distinctly to remember that pains taken and costs incurred for the purposes to which this Memorandum refers cannot in any event be regarded as

wasted trouble and expense. The local conditions which would enable Cholera, if imported, to spread its infection in this country, are conditions which day by day, in the absence of Cholera, create and spread other diseases: diseases which, as being never absent from the country, are, in the long run, far more destructive than Cholera: and the sanitary improvements which would justify a sense of security against any apprehended importation of Cholera would, to their extent, though Cholera should never re-appear in England, give amply remunerative results in the prevention of those other diseases.

JOHN SIMON,
Medical Officer of the Board.

Local Government Board,
July 5th, 1873.

IV.—GENERAL ORDER issued by the LOCAL GOVERNMENT BOARD in regard to the Prevention of the Spread of CHOLERA, July 1873.

Definitions.

Art. 1.—In this Order:—

The term "Ship" includes vessel or boat;

The term "Officer of Customs," includes any person having authority from the Commissioners of Customs;

The term "Master" includes the officer or person for the time being in charge or command of a ship;

The term "Cholera" includes Choleraic Diarrhœa;

The term "Sanitary Authority" has the same meaning as in "The Public Health Act, 1872;"

The term "Clothing and Bedding" includes all clothing and bedding in actual use and worn or used by the person attacked, at the time of or during the attack of Cholera.

For the purposes of this Order, every ship shall be deemed infected with Cholera, in which there is or has been during the voyage or during the stay of such ship in a foreign port in the course of such voyage, any case of Cholera.

I.—*Regulations as to Customs Inspections.*

Art. 2.—If any Officer of Customs, on the arrival within the limits of any port in England of any ship, ascertains from the master of such ship or otherwise, or has reason to suspect, that the ship is infected with Cholera, he may detain such ship, and order the master forthwith to moor or anchor the same; and thereupon the master shall forthwith moor or anchor the ship in such position as such Officer of Customs shall direct.

Art. 3.—Whilst such ship shall be so detained, no person shall leave the same.

Art. 4.—The officer of Customs detaining any ship as aforesaid, shall forthwith give notice thereof, and of the cause of such detention, to the Port Sanitary Authority, if there be one, or otherwise to the Sanitary Authority of the District within which the ship shall be detained.

Art. 5.—Such detention by the Officer of Customs shall cease as soon as the said ship shall have been duly visited and examined by the proper Officer of the Sanitary Authority; or, if the ship shall, upon such examination, be found to be infected with Cholera, as soon as the same shall be anchored or moored in pursuance of Art. 9 of this Order.

Provided, that if the examination be not commenced within twelve hours after notice given as aforesaid, the ship shall, on the expiration of the said twelve hours, be released from detention.

II.—*Regulations as to Sanitary Authorities.*

Art. 6.—The Port or other Sanitary Authority at every port shall, as speedily as practicable, with the approval of the Chief Officer of Customs of such port, fix some place or places within the said port where any ship may be detained, moored, or anchored, for the purpose of these regulations.

Art. 7.—Any officer appointed by such Sanitary Authority to see to the carrying out of this Order, if he have reason to believe that any ship arriving within the district of such Authority, whether examined by the Officer of Customs or not, is infected with Cholera, or shall have come from a place infected with Cholera, may visit and examine such ship, for the purpose of ascertaining whether it is so infected; and the Master of such ship shall suffer the same to be so visited and examined.

Art. 8.—The Sanitary Authority, on notice being given to them by an Officer of Customs, under this order, shall forthwith cause the ship in regard to which such notice shall have been given, to be visited and examined by their Medical Officer of Health, or some other legally qualified Medical Practitioner, for the purpose of ascertaining whether it is infected with Cholera.

Art. 9.—The master of every ship which is infected with Cholera shall, after any such examination as aforesaid, as long as the ship is within the District of a Sanitary Authority, moor or anchor her in such position as from time to time the said Authority shall direct.

Art. 10.—No person shall leave any such ship until the examination hereinafter mentioned shall have been made.

Art. 11.—The Sanitary Authority shall, as soon as possible after the arrival of any such ship, cause all persons on board of the same to be examined by their Medical Officer of Health, or some other legally qualified Medical Practitioner, and shall permit all persons who shall not be certified by him, as hereafter mentioned, to land immediately.

Art. 12.—Every person certified by the Medical Officer of Health or Medical Practitioner making such examination to be suffering from Cholera, shall be dealt with under any rules that may have been made by the Sanitary Authority under the 29th section of the Sanitary Act, 1866, or where no such rules shall have been made, shall be removed, if the condition of the patient admit of it, to some hospital or place previously appointed for such purpose by the said Authority; and no person so removed shall leave such hospital or place until the Medical Officer of Health of the Authority, or some other legally qualified Medical Practitioner appointed by them, shall have certified that such person is free from the said disease.

If any person suffering from Cholera cannot be removed, the ship shall remain subject, for the purposes of this Order, to the control of the Medical Officer of Health, or some other legally qualified Medical Practitioner appointed by the said Authority; and the infected person shall not be removed from or leave the ship, except with the consent in writing of the Medical Officer of Health or other Medical Practitioner.

Art. 13.—Such Medical Officer of Health or Medical Practitioner shall give directions, and take such steps as may appear to him to be necessary, for preventing the spread of the infection,

and the Master of the said Ship shall forthwith carry into execution such directions as shall be given to him by such Officer or Practitioner.

Art. 14.—Any person certified by such Medical Officer of Health or Medical Practitioner as aforesaid to be suffering from any diarrhœal or other illness, which he may suspect to be Cholera, may either be detained on board the ship or taken to some hospital or other previously appointed place, and detained there, for any period not exceeding two days, until it be ascertained whether the illness is or is not Cholera.

Any such person who, while so detained, shall be certified by the Medical Officer of Health or Medical Practitioner to be suffering from Cholera, shall be dealt with as in the above Article relating to patients suffering from that disease.

Art. 15.—In the event of any death from Cholera taking place on board of such vessel while so detained, the Master shall cause the dead body to be taken out to sea, and committed to the deep, properly loaded to prevent its rising. .

Art. 16.—The Master shall cause the clothing and bedding of every person who may have suffered from Cholera on board such vessel, or who, having at any time been on board such vessel, shall have suffered from Cholera during the stay of such vessel in a Foreign Port, to be disinfected or (if necessary) destroyed ; and if the Master shall have neglected to do so before the ship arrives in port, he shall forthwith, or upon the direction of the said Authority, cause the same to be disinfected or destroyed, as the case may require ; and if the said Master neglect to comply with such direction within a reasonable time, the Authority shall cause the same to be carried into execution.

Art. 17.—The Master shall cause every part of the ship, and every article therein, other than those last described, which may probably be infected with Cholera, to be disinfected or destroyed, when required to do so by the said Authority, or by their Medical Officer of Health.

V.—MEMORANDUM on the steps specially requisite to be taken by Boards of Guardians under the Vaccination Acts, 1867 and 1871, in places in which SMALL-POX is Epidemic.

As it is by Vaccination that the spread of Small-Pox can most effectually be prevented, Boards of Guardians, as soon as any case of that disease is brought into or occurs in their respective Unions or Parishes, should see that measures are promptly taken to secure, as far as necessary, the Vaccination (or, as the case may be, Re-Vaccination) of all such persons as are specially exposed to the danger of the infection.

Under the Order of Privy Council of February 18*th*, 1868 (*Reg. I. Art.* 1), *the Public Vaccinator is authorised to vaccinate, elsewhere than at the Public Station, cases in which there exists a special reason (to be noted by him in his Register) for taking this exceptional course; and sect.* 13 *of* 34 *and* 35 *Vict. c.* 98, *provides that District Medical Officers in attendance upon any person suffering from Small-Pox shall be entitled to payment from the Guardians for vaccinating or (as the case may be) re-vaccinating any person who is resident in the same house as such sick person, and who could lawfully be vaccinated or (as the case may be) re-vaccinated by a Public Vaccinator at the public expense.*

These provisions, promptly applied on the occurrence of any isolated case or cases of Small-Pox, will in general be found adequate to stop the further spread of the disease; but if from neglect of them, or from any other circumstance, cases of Small-Pox shall have become numerous, special measures (as below explained) should be taken to expedite, as far as practicable, the Vaccination of all un-vaccinated persons in the district, and to promote the Re-Vaccination of adults and adolescents who have not already been successfully re-vaccinated; and special arrangements (as below explained) may also be requisite to facilitate the performance of public Vaccination and Re-Vaccination.

This Memorandum is intended to afford information on those measures and arrangements.

I.—Special Instructions to Vaccination Officers.

1. At times when Small-Pox is epidemic, the Vaccination Officer should give his first and special attention to the particular localities in which the infection exists.

2. In order that for this purpose he may have the earliest possible information of the occurrence of cases of the disease, the Guardians should instruct their District Medical Officers to give him immediate notice of every fresh case of Small-Pox which comes under their treatment, and should also arrange with the Registrars of Deaths to forward to him immediate notice of each death registered from Small-Pox. For convenience of transmitting such notices, each District Medical Officer and Registrar should be supplied with forms duly stamped for post, or with post-cards adapted for the purpose. Private medical practitioners should also be invited to give similar information.

3. In each locality in which the infection exists, the Vaccination Officer should, with the utmost possible despatch, personally ascertain what children are unprotected by Vaccination, and should use his utmost exertions to obtain the prompt Vaccination of all such children. Generally speaking, his own judgment and local knowledge will guide him as to the manner in which his inquiries can best be made; but in infected courts or alleys, as well as certain kinds of streets, inquiries from house to house, and, in tenement-houses, from room to room, will be indispensable.

4. Where any child (between the ages of 3 months and 14 years) is found illegally unvaccinated, the Vaccination Officer should give a notice requiring the Vaccination to be done within a specified period. This period, when there is Small Pox in the house, or other special risk of exposure to the contagion, should not exceed twenty-four hours; but in other cases some days, not exceeding a week, may be allowed. A second visit from the Vaccination Officer will, of course, afterwards be necessary, in order to see that his notice has been complied with.

With regard to unvaccinated children, not yet 3 months old, who may be in infected localities, the Vaccination Officer should advise the parents not to incur the unnecessary risk of waiting for the child to complete that age before having its Vaccination performed; for Vaccination is perfectly well borne by children even immediately after birth. In no house in which there is

Small-Pox ought a child, however young, on any account to remain unvaccinated, unless on medical examination it be pronounced unfit to be vaccinated.

5. The Vaccination Officer should make it well known in infected localities that the Public Vaccinator is at liberty to re-vaccinate grown-up and young persons (not under 12 years of age) who have not before been successfully re-vaccinated, and who apply to him for that purpose: and that persons not vaccinated since childhood, who are likely to be exposed to contagion, ought to be re-vaccinated without delay. Above all, this is necessary for persons whose original marks of Vaccination are imperfect.

6. All notices given and representations made as above should be accompanied with information as to the provisions made for public Vaccination in the district. If any case requiring prompt Vaccination by the Public Vaccinator cannot, in the judgment of the Vaccination Officer, properly be taken to the station or to the residence of the Public Vaccinator, the Vaccination Officer should give to the Public Vaccinator immediate information of the case.

7. Besides the above-described special proceedings in localities already infected, the Vaccination Officer should take every means to ensure that the vaccination of his district generally is as complete as possible. He should make frequent examination of his birth-lists, and deal, as soon as practicable, with every default as it arises; and he should be prompt and diligent in his inquiries respecting the other children to whom his duties extend under Sections 11 and 17 of his "Instructions," as issued by the Local Government Board.

II.—*Special Arrangements for Public Vaccination.*

1. In towns which have regular weekly attendances for the performance of Public Vaccination, the only modification usually requisite will consist in the Vaccinators giving special daily attendances at the station at a fixed hour for the VACCINATION OF CASES OF EMERGENCY.

[Where the town-district is of particularly large population (so that the ordinary average weekly number of primary Vaccinations performed at the Station exceeds twenty), it may be convenient that during the stress of the epidemic the station should be open for the general performance of Vaccination on two days (instead of one day) in each week.]

It must, however, be distinctly understood that the daily attendances given as above are *only* for cases of emergency, and that cases which are not of emergency must be left to the times of general Vaccination.

It is on the regular weekly attendances that the Vaccinator has to depend not only to maintain the usual performance of primary Vaccination from arm to arm, but also to furnish lymph for cases of re-vaccination and for use in his special attendances; and the experience of every recent epidemic of Small-Pox has shown that to attempt at such times an indiscriminate daily performance of Vaccination and re-vaccination leads only to difficulties and disadvantages. There are two reasons, indeed, for which at such times an adherence to systematic arrangements (with exception only for special cases) is of more than ordinary consequence; first, because it is then peculiarly important that each primary Vaccination should be done under conditions which scarcely admit of failure; and, secondly, because without system it is quite impossible properly to meet the large demands for re-vaccination which at such times are sure to arise. Re-vaccinations, unless of persons residing in houses in which there is Small-Pox, or under other exceptional circumstances, should always be reserved for the regular Vaccinating Days.

2. In districts (whether of town or country) which ordinarily have their public Vaccinations performed at quarterly or half-yearly or other intervals, should Small-Pox break out at a time of year when Vaccination is not going on, it will be necessary that the station for the district, or part of district, in which the disease is prevailing should at once be opened, and that a WEEKLY ATTENDANCE should be given thereat for a limited period; during which period the Vaccination Officer should take steps as above directed for making the Vaccination of the district, or part of district, as complete as possible. In districts of the kind now under consideration it will probably be more convenient that CASES OF EMERGENCY should be vaccinated at their own homes under the exceptional provisions of Regulation 1, Article 1, of the Order of Feb. 18, 1868 above referred to) than that daily attendances should be given at the station.

3. Any exceptional Vaccination arrangements made as above by the Guardians with reference to epidemics of Small-Pox should be for some fixed period, not exceeding six weeks; at the end of which period they can, in case of need, be renewed

by a further order of the Guardians; but every such making or renewal of the exceptional arrangements should be reported without delay to the Local Government Board.

Medical Department of the Local Government Board,
July 1873.

VI.—Memorandum on Re-Vaccination.

By vaccination in infancy, if thoroughly well performed and successful, most people are completely insured, for their whole lifetime, against an attack of small-pox; and in the proportionately few cases where the protection is less complete, small-pox, if it be caught, will, in consequence of the vaccination, generally be so mild a disease as not to threaten death or disfigurement. If however the vaccination in early life have been but imperfectly performed, or have from any other cause been but imperfectly successful, the protection against small-pox is much less satisfactory; neither lasting so long, nor while it lasts being nearly so complete, as the protection which first-rate vaccination gives. Hitherto, unfortunately, there has always been a very large quantity of imperfect vaccination; and in consequence the population always contains very many persons who, though nominally vaccinated and believing themselves to be protected against small-pox, are really liable to infection, and may in some cases contract as severe forms of small-pox as if they had never been vaccinated. Partly because of the existence of this large number of imperfectly vaccinated persons, and partly because also even the best infantine vaccination sometimes in process of time loses more or less of its effect, it is advisable that *all persons who have been vaccinated in infancy should, as they approach adult life, undergo* Re-Vaccination. Generally speaking, the best time of life for re-vaccination is about the time when growth is completing itself, say from 15 to 18 years of age; and persons in that period of life ought not to delay their re-vaccination till times when there shall be special alarm of small-pox. In proportion, however, as there is prevalence of small-pox in any neighbourhood, or as individuals are from personal circumstances likely to meet chances of infection, the age of 15 need not be waited for;

especially not by young persons whose marks of previous vaccination are unsatisfactory. *In circumstances of special danger, every one past childhood, on whom re-vaccination has not before been successfully performed, ought without delay to be re-vaccinated.*

Re-vaccination, once properly and successfully performed, *does not appear ever to require repetition.* The nurses and other servants of the Small-Pox Hospital when they enter the service (unless it be certain that they have already had small-pox) are invariably submitted to vaccination, which in their case generally is re-vaccination, and is never afterwards repeated; and so perfect is the protection, that though the nurses live in the closest and most constant attendance on small-pox patients, and though also the other servants are in various ways exposed to special chances of infection, the Resident Surgeon of the Hospital, during his thirty-four years of office there, has never known small-pox affect any one of these nurses or servants.

Legal Provisions for Re-vaccination are made in the 8th Section of the Vaccination Act, 1867, and in Section IV. of the Regulations which the Lords of the Council under Authority of the Act issued in their Order of February 18th, 1868. Under these provisions, *Re-vaccination is now performed by all Public Vaccinators at their respective Vaccinating-Stations;* and, so far as is not inconsistent with the more imperative claims for primary vaccination, *any person who ought to be re-vaccinated may, on applying to the Public Station of the District in which he resides, obtain Re-vaccination at the public expense.*

Where Medical Practitioners, not being Public Vaccinators, and not having otherwise in their practice cases for Primary Vaccination, are called upon to re-vaccinate on considerable scale (as in hospitals, commercial establishments, schools, and even large households), they would generally find it best to make direct application for assistance to the Public Vaccinator of the District in which they have to act; with whose assistance they may commonly find it in their power to arrange with the parents of children recently vaccinated at the Public Station, that some of such children shall at the proper time be taken to places where private re-vaccinations have to be performed, so as to furnish from arm to arm any required quantity of lymph. Generally, too, any private Medical Practitioner who, from any cause, desires to obtain extraordinary supplies of lymph, will most easily attain his object by applying to the Public Vaccinator

of the District in which he resides. And as Public Vaccinators, appointed under the Vaccination Act, 1867, are of course free to accept payment for any extra-official work which they may be willing to undertake, Private Practitioners would probably have no difficulty in obtaining, by voluntary agreement, the assistance of some of these officers as collectors of lymph for private re-vaccination.

It is important for the Public to observe that Re-vaccination on a large scale is not easily conducted unless in a thoroughly systematic manner, and that individual difficulties in finding lymph for re-vaccination are inseparable from the too general practice of deferring re-vaccination to periods of panic, instead of having it proceed, as it should, regularly and uniformly, in proportion as successive numbers of population reach the proper age for its performance.

February 6th, 1871.

VII.—Instructions of the Local Government Board for Vaccinators under Contract.

1. Except so far as immediate danger of small-pox may require, vaccinate only subjects who are in good health. As regards infants, ascertain that there is not any febrile state, nor any irritation of the bowels, nor any unhealthy state of skin; especially no chafing or eczema behind the ears, or in the groin, or elsewhere in folds of skin. Do not, except of necessity, vaccinate in cases where there has been recent exposure to the infection of measles or scarlatina, nor where erysipelas is prevailing in or about the place of residence.

2. In all ordinary cases of primary vaccination, if you vaccinate by separate punctures, make such punctures as will produce at least four separate good-sized vesicles, not less than half an inch from one another; or, if you vaccinate otherwise than by separate punctures, take care to produce local effects equal to those just mentioned.

3. Direct care to be taken for keeping the vesicles uninjured during their progress, and for avoiding afterwards the premature removal of the crusts.

4. Enter all cases in your register on the day when you vaccinate them, and with all particulars required in the register up to column 9 inclusive. Enter the results on the day of inspection. Never enter any results which have not been inspected by yourself or your legally-qualified deputy. In cases of primary vaccination, register as "successful" only those cases in which the normal vaccine vesicle has been produced; in cases of re-vaccination, register as "successful" only those cases in which either vesicles, normal or modified, or papules surrounded by areolæ, have resulted. When the vaccination of an unsuccessful case is repeated, it should be entered as a fresh case in the register.

5. Endeavour to maintain in your district such a succession of cases as will enable you uniformly to vaccinate with liquid lymph directly from arm to arm; and do not, under ordinary circumstances, adopt any other method of vaccinating. To provide against emergencies, always have in reserve some stored lymph;—either *dry*, as on thickly-charged ivory points, constantly well protected from damp; or *liquid*, according to the method of Dr Husband of Edinburgh, in fine, short, uniformly capillary (not bulbed) tubes, hermetically sealed at both extremities. Lymph, successfully preserved by either of these methods, may be used without definite restriction as to time; but with all stored lymph caution is necessary, lest in time it have become inert, or otherwise unfit for use. If in order to vaccinate with recent liquid lymph, you convey it from case to case otherwise than in hermetically-sealed capillary tubes, do not ever let more than eight hours intervene before it is used.

6. Consider yourself strictly responsible for the quality of whatever lymph you use or furnish for vaccination. Never either use or furnish lymph which has in it any, even the slightest, admixture of blood. In storing lymph, be careful to keep separate the charges obtained from different subjects, and to affix to each set of charges the name, or the number in your register, of the subject from whom the lymph was derived. Keep such note of all supplies of lymph which you use or furnish, as will always enable you, in any case of complaint, to identify the origin of the lymph.

7. Never take lymph from cases of re-vaccination. Take lymph only from subjects who are in good health, and, as far as you can ascertain, of healthy parentage; preferring children

whose families are known to you, and who have elder brothers or sisters of undoubtful healthiness. Always carefully examine the subject as to any existing skin-disease, and especially as to any signs of hereditary syphilis. Take lymph only from well-characterised, uninjured vesicles. Take it (as may be done in all regular cases on the day week after vaccination) at the stage when the vesicles are fully formed and plump, but when there is no perceptible commencement of areola. Open the vesicles with scrupulous care to avoid drawing blood. Take no lymph which, as it issues from the vesicle, is not perfectly clear and transparent, or is at all thin and watery. From such a vesicle as vaccination by puncture commonly produces, do not, under ordinary circumstances, take more lymph than will suffice for the immediate vaccination of five subjects, or for the charging of seven ivory points, or for the filling of three capillary tubes; and from larger or smaller vesicles take only in like proportion to their size. Never squeeze or drain any vesicle. Be careful never to transfer blood from the subject you vaccinate to the subject from whom you take lymph.

8. Scrupulously observe in your inspections every sign which tests the efficiency and purity of your lymph. Note any case wherein the vaccine vesicle is unduly hastened or otherwise irregular in its development, or wherein any undue local irritation arises; and if similar results ensue in other cases vaccinated with the same lymph, desist at once from employing it. Consider that your lymph ought to be changed, if your cases, at the usual time of inspection on the week day after vaccination, have not, as a rule, their vesicles entirely free from areolæ.

9. Keep in good condition the lancets or other instruments which you use for vaccinating, and do not use them for other surgical operations. When you vaccinate, have water and a napkin at your side, with which invariably to cleanse your instrument after one operation before proceeding to another.

JOHN SIMON.

July 29th, 1871.

VIII.—Suggestions by the Society of Medical Officers of Health, for Preventing the Spread of Infectious or Contagious Diseases, such as Scarlet Fever, Small-pox, Fever, etc.

1. Separate the sick person from the rest of the family directly illness appears, placing him, if possible, in a room at the top of the house, and taking care to remove carpets, curtains, and all unnecessary articles of furniture and clothing therefrom.

2. Admit fresh air by opening the upper sash of the window. The fireplace should be kept open, and a fire lighted if the weather permits. Fresh air should be freely admitted through the whole house by means of open windows and doors. The more air that passes through the house, the less likely is the disease to spread.

3. Hang up a sheet outside the door of the sick-room, and keep it wet with a mixture made either with a quarter of a pint of carbolic acid (No. 4), or a pound of chloride of lime, and a gallon of water.

4. Everything that passes from the sick person should be received into vessels containing half a pint of a solution of green copperas, made by dissolving one pound of the copperas in a gallon of water. A like quantity of the solution of copperas should be added to the discharges before emptying them into the closet.

5. Every sink, closet, or privy should have a quantity of one of the above-named disinfectants poured into it daily, and the greatest care should be taken to prevent the contamination of well or drinking water by any discharges from the sick person.

6. All cups, glasses, spoons, etc., used by the sick person should be first washed in the above-named solution of carbolic acid, and afterwards in hot water, before being used by any other person.

7. No article of food should be allowed to remain in the sick-room. No food or drink that the sick person has tasted, or that has been in the sick-room, should be given to any one else.

8. All bed and body linen, as soon as removed from the sick person, and before being taken from the room, should be first put into a solution of carbolic acid of the above-mentioned strength, remaining therein for at least an hour, and afterwards boiled in water.

9. Instead of handkerchiefs, small pieces of rag should be used, and these, when soiled, should be immediately burnt.

10. Persons attending on the sick should not wear woollen garments, as they are likely to retain infectious poison; dresses of cotton, or of some washable material, should be worn. Nurses should always wash their hands immediately after attending to the sick person, using carbolic acid soap instead of ordinary soap.

11. It is of the utmost importance that the sick-room be not frequented by others than those in immediate attendance on the sick, as the clothing of visitors is very liable to carry away infection.

12. The scales and dusty powder which peel from the skin in scarlet fever, and the crusts in small-pox, being highly infectious, their escape may be prevented by smearing the body of the sick person all over every day with camphorated oil. This, and the after use of warm baths and carbolic acid soap, are most essential. The sick person must not be allowed to mix with the rest of the family until the peeling has *entirely ceased*, and the skin is perfectly smooth; clothes used during the time of illness, or in any way exposed to infection, *must not be worn again until they have been properly disinfected.*

13. When the sickness has terminated, the sick-room and its contents should be disinfected and cleansed. This should be done in the following manner:—Spread out and hang upon lines all articles of clothing and bedding; well close the fireplace, windows, and all openings; then take a quarter to half a pound of brimstone, broken into small pieces; put them into an iron dish, supported over a pail of water, and set fire to the brimstone, by putting some live coals upon it. Close the door, and stop all crevices, and allow the room to remain shut up for twenty-four hours. The rooms should then be freely ventilated, by opening the door and windows, the ceiling should be whitewashed, the paper stripped from the walls and burnt, and the furniture, and all wool and painted work be well washed with soap and water containing a little chloride of lime. Beds,

mattresses, and articles which cannot well be washed, should, if possible, be submitted to the action of heat in a disinfecting chamber, usually provided by the local authorities. *Until this process of disinfection is effectually carried out, the room cannot be safely occupied.*

14. Children should not be allowed to attend school from a house in which there is infectious disease, as, although not ill themselves, they are very likely to carry the infection, and so spread the disease. No child should be allowed to re-enter a school without a certificate from the medical attendant, stating that he can do so without any danger of infecting other children.

15. In case of death, the body should not be removed from the room, except for burial, unless taken to a mortuary, nor should any article be taken from it until disinfected as before directed in Rule No. 13. The body should be put into a coffin as soon as possible, with a pound or two of carbolic powder. The coffin should be fastened down, and the body buried without any delay.

Attention is particularly directed to the following provisions of the Sanitary Laws, in reference to "Infectious Disorders":—

1. The owner or occupier may be required to cleanse and disinfect any house or room, or the cabin or berth of any ship or vessel, and the articles contained in it likely to retain infection—where infectious disease has existed—under a penalty not exceeding 10s. a day for neglect.

2. If any person, suffering from any dangerous infectious disorder, shall enter a cab or other public conveyance, without informing the driver thereof that he is so suffering, he shall be liable to a penalty not exceeding £5.

3. Any person suffering from any dangerous infectious disorder—such as fever, scarlet fever, small-pox, etc.—who exposes himself in any street, school, church, chapel, theatre, or other public place; or in any omnibus or other public conveyance; and any person in charge of one so suffering, who so exposes the sufferer, shall be liable to a penalty not exceeding £5.

4. Any person who, without previous disinfection, gives, lends, sells, or moves to another place, or exposes, any bedding, clothing, rags, or other things which have been exposed to infection, becomes liable to a penalty not exceeding £5.

5. Any person who lets a house, room, or part of a house, in which there has been infectious disease, without having such house or room, and all articles therein liable to infection, disinfected to the satisfaction of a qualified medical practitioner, is liable to a penalty not exceeding £20. This applies to public-houses, hotels, and lodging-houses.

6. If any person who lets, or shows for hire, any house or part of a house, makes any *false statement* as to the fact of there being then in such house, or having within six weeks previously been therein, any person suffering from an infectious disease, such person *answering falsely* shall be liable to imprisonment, with or without hard labour, or to a penalty not exceeding £20.

J. Northcote Vinen, M.D., *St. John's, Southwark,*
W. H. Corfield, M.D. (Oxon.) *10 Bolton Row, Mayfair,*
Hon. Secs.

March 1875.

IX.—Circular Letter addressed to the Clerks of the Guardians of the Poor and Sanitary Authorities, with respect to Death-returns, etc.

Local Government Board, Whitehall, S.W.
23d March 1874.

Sir—I am directed by the Local Government Board to call the attention of the Rural Sanitary Authority to sub-sections 14 and 15 of section 4 of their General Order of the 11th November 1872, which require that every Medical Officer of Health, whose appointment has been approved by the Board, shall prepare an annual Report, comprising, amongst other things, tabular statements of the sickness and mortality in his district; and shall also transmit to the Board, on forms to be provided by them, a quarterly return of the sickness and death within such district. In order to enable Medical Officers of Health to discharge this duty efficiently, the Board consider it essential that they should be supplied, by the Registrar of Births and Deaths, with returns of the deaths registered within their respective districts; and the Board trust that the Rural Sanitary Authority will make the necessary arrangements for that purpose. These returns should be made weekly as regards all deaths registered as having occurred within the Registrar's district during the preceding week; but an immediate notice should be given of all deaths from infectious disease in fresh localities, and of all groups of deaths from such disease, or from diarrhœa, in any localities. As there is no statutory provision that the Registrars shall supply such returns gratuitously, and it appears just that these officers should be paid a reasonable compensation for the additional labour thus entailed upon them, the Board have consulted the Law officers of the Crown as to the legality of the payment of such compensation by the Sanitary Authorities, and the Law Officers have advised that the Sanitary Authorities may lawfully pay for the returns referred to. With regard to the amount of such compensation, the Board suggest that, in accordance with a proposal made in the Registration of Births and Deaths Bills of the last Session, and which passed the House of Lords, it should be fixed at the rate of 2d. for each death entered in the return.

The Board direct me further to point out, that when the Medical Officers of Health are not also the Poor-Law Medical Officers, they will require information from the books of the latter with respect to all new cases of sickness within their respective districts, both in order that they may be cognisant of the sanitary condition of the pauper class, and may be enabled to prepare their quarterly and annual reports in conformity with the regulations of the Board ; and the Board, therefore, consider it desirable that the Guardians should instruct their Clerk to copy from the District Medical Officer's relief lists the new cases which are reported at each meeting of the Guardians, and forward the same promptly and regularly to the Medical Officer or Officers of Health within the Union. It is very important that this information should reach the Medical Officers of Health without delay, and the Board trust that arrangements will be made for the regular transmission of the copies referred to as early as practicable after each meeting. I am directed to add that the Board recommend that the Guardians should request the Poor-Law Medical Officers to give to the Medical Officer of Health, or Inspector of Nuisances, acting within their respective districts, the earliest possible information of cases of dangerous infectious disease under their charge ; as it is evident that unless such information is given as soon as the cases occur, the action of the Sanitary Authority, in regard to the prevention of contagion, must often fail in its effect. —I am, Sir, your obedient servant, JOHN LAMBERT.

X.—FORM of REGISTRAR'S WEEKLY RETURN of BIRTHS and DEATHS, Merthyr-

REGISTRATION DISTRICT OF____________________

Return of Number of Births and Deaths during the Week ending

BIRTHS { Legitimate, M.________ F.______ = ______
Illegitimate, M.________ F.______ = ______ } Total______

PARTICULARS OF DEATHS

Register No.	When died.	Residence.	Names.	Sex.

To the Medical Officer of Health,

arranged by T. J. Dyke, Esq., F.R.C.S., Medical Officer of Health, Tydfil.

SUB-DISTRICT OF ______________________

Saturday, the __________ *day of* __________ 18

Deaths—Male ______ Female ______ = ______ Total.

> **The Medical Officer will be glad to have this return every Monday.**

REGISTERED IN THE WEEK.

Age.			Occupation.	Causes of Death.		Duration of Diseases.		Certified, or not; or Inquest.
Years.	Months.	Days.		1	2	1	2	

Signed , Registrar.

I.—Clerk's Fortnightly Return to the Medical Officer of Health of all new Cases of Sickness and Deaths appearing from time to time in the Report Books of the several District Medical Officers of the ____________ Union. (*Author's Form.*)

*Fortnight ended*____________________________187

Name.	Age.	Residence.	Disease.	In-door.	Out-door.	Deaths.	Remarks.

Date, Signed,

Clerk to the Guardians.

XII.—Notice of Infectious Diseases occurring amongst Paupers.

(*Author's Form.*)

______________Sanitary Authority.

Return of District Medical Officer.

Name.	Age.	Residence.	Disease.	Probable Cause.	Steps recommended.

To be folded and forwarded, unsealed, to Sanitary Inspector.

Signed,

District Medical Officer.

Date,

Return of Sanitary Inspector.

Sanitary Condition of Premises.	Action taken.

To be folded and forwarded, unsealed, to Medical Officer of Health.

Signed,

Sanitary Inspector.

Date,

Explanatory Note.—The above form should be printed on paper foolscap size, with the Returns of the District Medical Officer and Sanitary Inspector on one side, and the addresses of the Medical Officer of Health and Sanitary Inspector on the other.

XIII.—REPORT of the SOCIETY of MEDICAL OFFICERS of HEALTH on the STATISTICAL RETURNS in the ANNUAL REPORTS of MEDICAL OFFICERS of HEALTH.

The attention of the Society was, some time since, directed to the desirability of an uniform system being adopted in the Statistical Returns of Metropolitan Medical Officers of Health; and the following Resolution was agreed to:—"That it be referred to the Council to consider as to the desirability of the Statistical Returns in the Annual Reports of the Metropolitan Medical Officers of Health being based on an uniform system, and to frame suggestions for carrying out such a system, if found desirable."

The consideration of the subject was afterwards enlarged, in order to make the system practicable for *all* Medical Officers of Health in London and the country, and the Tables recommended by the Council were framed with that object.

The Council was assisted in its deliberations by the statistical information given in the Annual Reports of both Metropolitan and Provincial Medical Officers of Health, by some retired Medical Officers of Health, and eminent Sanitarians.

The Recommendations of the Council were finally adopted by the Society at the last May meeting.

The Society is unanimously of opinion that it is desirable the statistical returns of all Medical Officers of Health in England and Wales should be based on an uniform system, and the following tables are put forth as skeleton models which may be, and it is hoped will be, adopted by all medical Officers of Health. The tables are no doubt susceptible of improvement; but their adoption in the present form is urged, as it is believed that any disadvantages they may possess are outweighed by the advantages resulting from an uniform system which admits of the direct comparison of the statistical returns of two or more districts. It is not intended that these tables *only* should be used by Medical Officers of Health, but that at least the information here sketched out may be given for all districts, and in the form here set forth. Other tables may be added at the discretion of Medical Officers of Health.

It is thought desirable, and asked that:—

1. All statistical returns be made out to the end of the

registration year, as defined in the Registrar-General's Reports (Dec. 31st, or thereabouts).

2. That, merely for the sake of uniformity and convenience of compilation, the head of columns for tables be as far as possible identical with those used in the Registrar-General's tables.

3. That the numbers of the tables adopted by the Society be in all cases appended to these tables when used; and that, to avoid confusion, different numbers be assigned to any other tables which it may be thought fit to insert in an Annual Report.

The following explanations of the purport of the several tables may be of service :—

TABLE I.—This table merely gives gross numbers, and the statistics of the year under notice and the ten preceding years, *when these are attainable.*

TABLE II.—This is a table of death rates, and of deaths (gross) in Public Institutions. It is, like Table I., also retrospective ; and it is hoped that as many of the statistics of back years may be given as it is possible to obtain.

TABLE III.—This is an abreviated copy of the Registrar-General's long table, which is deemed unnecessary to set out at full length. The "etc. etc.," below the word "Syphilis," at the bottom of the first column means that the long list of diseases set out in the Registrar-General's table is to be inserted in *full.*

TABLE IV.—This relates to the year under notice only, and needs no further explanation.

TABLE V.—This table is intended to afford a comparison of the mortality from the chief zymotic diseases of the year under notice with that of the antecedent years.

Table I.—*Population, Inhabited Houses, Births, Deaths, and Marriages.*

(Gross Numbers.)

Population estimated at the middle of the Year 18 *	No. of Inhabited Houses in Parish or District.	Births.	Deaths.* *	Marriages.
1873.				
1872........................	....	....	....	....
1871........................	....	....	....	....
1870........................	....	....	....	....
1869........................	....	....	....	....
1868........................	....	....	....	....
1867........................	....	....	....	....
1866........................	....	....	....	....
1865........................	....	....	....	....
1864........................	....	....	....	....
1863........................	....	....	....	....
Average of 10 years, 1863–1872............				

NOTES.

1. Population at Census 1871..................
2. Area in Acres............
3. Average No. of Persons in each house at Census 1871.........

* For statistical purposes the Registrar-General estimates the population to the middle of the year as the basis of the rate of increase ruling between the two preceding Census periods. The estimate of population may be checked by the known number of inhabited houses, and by the average number of inmates per house, as ascertained at the preceding Census.

* * The deaths of non-parishioners in public institutions within the parish should be deducted, but a proportion of the deaths occurring in General Hospitals, relative to the population of the parish or district, should be added to the total number of deaths in this column.

TABLE II.—*Annual Rate of Mortality, Death Rates among Children, and Deaths in Public Institutions.*

	Annual Rate of Mortality per 1000 living.	Deaths of Children under 1 year: percentage to Total Deaths.	Percentage of Deaths of Children under 1 year to Registered Births.	Deaths of Children under 5 years: per cent to Total Deaths.	Percentage of Deaths in Public Institutions.
1873.					
1872					
1871					
1870					
1869					
1868					
1867					
1866					
1865					
1864					
1863					
Average of 10 years, 1863–1873					

LE III.—*Deaths registered at several groups of Ages from different Causes during the year* 187 ; *the deaths in Public Institutions of Non-residents being excluded.*

Cause of Death. Classes.	Ages.														Total.
	0 to 1	1 to 2	2 to 5	5 to 15	15 to 25	25 to 35	35 to 45	45 to 55	55 to 65	65 to 75	75 to 85	85 to 95	95 and upwards.	Total under 5 Years.	
I. Zymotic Diseases															
II. Constitutional Diseases															
III. Local Diseases															
IV. Developmental Diseases															
V. Violent Deaths															
Not specified or ill defined															
Totals															
I. Zymotic Diseases.															
Order 1.—*Miasmatic.*															
Smallpox															
Measles															
&c. &c.															
Other Zymotic Diseases															
Order 2.—*Enthetic.*															
Syphilis															
&c.															
&c.															

Note.—This Table is a copy of that used by the Registrar-General, and is to be extended to other diseases beyond those enumerated.

Table IV.—*Showing Mortality from certain classes of Diseases, and proportions to Population, and to* 1000 *Deaths*, 187 , *viz.*—

	Total Deaths.	Deaths per 1000 of Population.	Proportion of Deaths to 1000 Deaths.
1. Seven Principal Zymotic Diseases			
2. Pulmonary „ ... (*other than Phthisis*)			
3. Tubercular „ ...			
4. Wasting Diseases of Infants ...			
5. Convulsive Diseases of Infants ...			

NOTES.

1. Includes Smallpox, Measles, Scarlet Fever, Diphtheria, Whooping Cough, Fever, and Diarrhœa.
3. Includes Phthisis, Scrofula, Rickets, and Tabes.
4. Includes Marasmus, Atrophy, Debility, Want of Breast Milk, and Premature Birth.
5. Includes Hydrocephalus, Infantile Meningitis, Convulsions, and Teething.

Table V.—*Showing the Number of Deaths in the 10 years 186 to 187 , from the seven principal Zymotic Diseases, and the Number in 187 .*

Disease.	1863.	1[illegible]	1865.	[illegible]	1867.	1868.	1869.	1870.	1871.	1872.	Annual Average of 10 years, 1863-1872.	Proportion of Deaths to 1000 Deaths in 10 years, 1863-1872.	1873.	Proportion of Deaths to 1000 Deaths in 1873.
Smallpox ...														
Measles ...														
Scarlet Fever ...														
Diphtheria ...														
Whooping Cough ...														
Fever ...														
Diarrhœa ...														
Total ...														
London...														
England and Wales...														

[redacted]

Table VI.—*Inspector's Report of the Sanitary Work, &c., completed in the Year ending December* 31, 187 .

Total.	e. g. Regent's Park.	e. g. Oxford Street.	e. g. Gray's Inn.	e. g. Camden Town.	Sub-Districts.		
					No. of Complaints received during the year.		
					No. of Houses and Premises, &c., inspected.		
					Orders issued for Sanitary Amendments of Houses and Premises.		Results of Inspection.
					Houses and Premises, &c., Cleansed, Repaired, and Whitewashed.		Results of Inspection.
					Houses Disinfected after Infectious Diseases.		Results of Inspection.
					Repaired, Cleansed, &c.		House Drains.
					Trapped or Ventilated.		House Drains.
					Repaired, Cleansed, &c.		Privies and W.C.'s.
					Supplied with Water.		Privies and W.C.'s.
					New provided.		Privies and W.C.'s.
					New provided.		Dust Bins.
					Repaired, Covered, &c.		Dust Bins.
					Cisterns (new) erected.		Water Supply.
					Cisterns Cleansed, Repaired, and Covered.		Water Supply.
					No. of Lodging Houses registered under 35th Clause of Sanitary Acts, 1866.		Miscellaneous.
					No. of Dust Complaints received and attended to.		Miscellaneous.
					Removal of Accumulation of Dung, Stagnant Water, Animal and other Refuse.		Miscellaneous.
					Removal of Animals improperly kept.		Miscellaneous.
					Bakehouses.	Regularly Inspected.	Miscellaneous.
					Licensed Cowhouses.	Regularly Inspected.	Miscellaneous.
					Licensed Slaughterhouses.	Regularly Inspected.	Miscellaneous.
					Other Proceedings, e. g. Legal Proceedings.		Miscellaneous.

Note.—Intended for use in London, but may be modified according to circumstances for the country.

J. NORTHCOTE VINEN, M.D., St. John's, S.E.
THOS. STEVENSON, M.D., 21 Caversham Road, N.W.
Honorary Secretaries.

June 1874.

XIV.—Comparison of the Metrical with the Common English Measures, as regards Capacity and Weight, from Tables arranged by Mr. Warren de la Rue, F.R.S.

MEASURES OF CAPACITY.	In Cubic Inches.	In Cubic Feet = 1728 Cubic Inches.	In Pints = 34·65923 Cubic Inches.
Millilitre, or cubic centimetre .	0·061027	0·0000353	0·001761
Centilitre, or 10 cubic centimetres	0·610271	0·0003532	0·017608
Decilitre, or 100 cubic centimetres	6·102705	0·0035317	0·176077
Litre, or cubic decimetre . .	61·027052	0·0353166	1·760773
Decalitre, or centistere . .	610·270515	0·3531658	17·607734
Hectolitre, or decistere . .	6102·705152	3·5316581	176·077341
Kilolitre, or stere, or cubic metre	61027·051519	35·3165807	1760·775314
Myriolitre, or decastere . .	610270·515194	353·1658074	17607·734140

1 cub. in. = 16·3861759 cub. centimetres. 1 cub. ft. = 28·3153119 cub. decimetres.
1 fluid oz. = 28·4 c.c. 1 gallon = 4·543457969. 1 quart = 1·136 litre.

MEASURES OF WEIGHT.	In English Grains.	In Troy Ounces = 480 Grains.	In Avoirdupois Lbs. = 7000 Grains.
Milligramme	0·015432	0·000032	0·0000022
Centigramme	0·154323	0·000322	0·0000220
Decigramme	1·543235	0·003215	0·0002205
Gramme	15·432349	0·032151	0·0022046
Decagramme	154·323488	0·321507	0·0220462
Hectogramme	1543·234880	3·215073	0·2204621
Kilogramme	15432·348800	32·150727	2·2046213
Myriogramme	154323·488000	321·507267	22·0462126

1 Grain = 0·064798950 Gramme. 1 lb. Avd. = 0·45359265 Kilogr.
1 Troy oz. = 31·103496 Gramme. 1 Cwt. = 50·80237689 Kilogr.

XV.—List of Apparatus and Re-agents.

The following sets of apparatus and re-agents mentioned in different parts of the work may be obtained from various manufacturing chemists, such as Messrs. Griffin and Sons, Garrick Street, Covent Garden, London; Messrs. Townson and Mercer, Bishopsgate Street, London; Messrs. Sutton, Norwich; and Messrs. Harris and Co., Bull Ring, Birmingham. The prices quoted are of course subject to variation, and only approximately accurate :—

	About		
Chemical Balance	£3	15	0
Set of Gramme Weights, 50 Grammes to 1 Milligramme (Oertlings)	1	15	0

For the Examination of Air.

1-1 Litre Measure graduated into c.c.	0	9	0
4 Glass Jars to hold 5000 c.c. each . . .	1	2	0
1 India-rubber Caps for ditto (double set) . .	1	16	0
1 Tall narrow Glass, marked to measure 30 and 60 c.c.	0	2	3
1 Mohr's Burette 50 c.c. graduated into 1-10th .	0	5	9
1 Support for ditto (Mahogany)	0	5	0
1 Bellows Pump with long nozzle (length sufficient to reach the bottom of the jars) . . .	0	4	6
2 Mixing Jars 1 Pint	0	2	6
6 Glass Stirrers for ditto	0	0	9
4 oz. Turmeric Paper	0	0	6
1 Box of Filter Papers	0	2	0
1 Glass Funnel 4″	0	0	4
4 oz. Pure Cryst. Oxalic Acid	0	1	4
1 lb. Calcium Hydrate (for making lime water) .	0	1	1
2 Common wet and dry bulb Thermometer (Mason's) each	0	9	0

For the Qualitative Examination of Water.

2 Tall colourless glass Cylinders 2 ft. high 1″ diam.	0	10	0
1 Wide mouth colourless glass Flask to hold about 1000 c.c.	0	1	0

			About	
1	Nest (12) of Test Tubes	£0	1	6
1	Nest Porcelain Evaporating Basins, 2, 4, 8, and 16 oz.	0	3	6
1	Porcelain Crucible 2¼″ diam.	0	10	0
1	Set (6) Clark's Test Glasses 1 oz.	0	1	6
1	Set (6) Cylindrical Test Glasses 2 oz. . . .	0	2	0
	Apparatus for making sulphuretted hydrogen water (pint)	0	5	0
6	oz. Sol. Caustic Potash	0	2	1
6	„ „ Ammonium Oxalate	0	1	10
6	„ „ Barium Nitrate	0	1	4
6	„ „ Silver Nitrate	0	3	4
6	„ „ Nessler's Test Solution	0	2	5
6	„ „ Ammonia, strong	0	1	4
6	„ „ Acetic Acid	0	2	4
6	„ „ Nitric Acid, dilute	0	1	10
6	„ „ Sulphuric Acid, pure conctd. . . .	0	2	1
6	„ „ Hydrochloric Acid, dilute	0	1	7
2	„ Potassium Iodide	0	1	4
2	„ Potassium Permanganate	0	1	4
6	„ Ferrous Sulphide lumps	0	0	3
2	„ „ Sulphate	0	1	7

For the Quantitative Analysis of Water.

Balance and Weights as above.

1	Liebig's Condenser with stand	0	15	0
2	Retorts, each	0	3	6
1	Retort Stand	0	7	0
2	Burettes 50 c.c., and graduated 1-10th, each .	0	3	6
1	Burette 50 c.c., and graduated 1-10th with glass stop-cock	0	7	6
2	Pipettes, 2 c.c., each	0	0	6
2	Pipettes, 5 c.c. graduated 1-10th, each . .	0	1	6
2	Half-litre Flasks, each	0	1	6
2	Flasks to hold 70 c.c., each	0	1	0
2	Flasks to hold 35 c.c., each	0	0	6
6	Nessler Glasses, 50 c.c., each	0	1	6
1	Platinum Dish	4	0	0
1	Bunsen Burner	0	2	0

	About		
1 Wash-bottle	£0	1	6
Nitrate of Silver, pure per oz.	0	4	0
Permanganate of Potash „	0	0	8
Caustic Potash „	0	0	6
Soap test (Clark's) per lb.	0	4	0
Nessler Re-agent „	0	6	0
Chloride of Ammonium per oz.	0	0	6
Chromate of Potash „	0	0	3

For the Examination of Milk.

1 Lactometer graduated to test approximately the percentage of adulteration with water (in a case)	0	3	0
1 Tall narrow glass vessel graduated to test percentage of cream (in a case)	0	2	0

INDEX.

A

B

C

D

E

F

G

H

I

L

M

N

O

P

Q

R

S

T

THE END.

Printed by R. & R. Clark, *Edinburgh*.

૩૫૦

on or before the date last stamped below.

NAME 17594	DATE DUE